COMPOSITION OF VITAMINS AND AMINO ACIDS IN LATVIAN CRANBERRIES

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Abstract

Berries contain a diverse array of nutrients with recognized biological activities that promote or contribute to health. The content and diversity of vitamins is often the basis for promoting increased daily intake of berries. The current research focuses on the evaluation of vitamins and amino acid content in wild and cultivated cranberries grown in Latvia. The research was accomplished on fresh Latvia wild growing (*Vaccinium oxycoccus* L.) and cultivated cranberries (*Vaccinium macrocarpon* Ait.) harvested in Kurzeme region: wild cranberries and cranberries cultivars 'Early Black', 'Ben Lear', 'Stevens', 'Bergman' and 'Pilgrim'. The following quality parameters of cranberries were controlled using standard methods: vitamin E (AOAC 971.30), vitamin B_1 (AOAC 986.27), vitamin B_2 (AOAC 970.65), vitamin C (LVSEN 14130:2003), amino acids except tryptophan (ion-exchange method), tryptophan (spectrophotometric method). The results of current research demonstrate that very similar vitamin C content was detected in cranberry cultivars: 'Stevens', 'Bergman' and 'Ben Lear'. The lowest vitamin C content was detected in wild cranberries and cranberry cultivar 'Early Black', 46.98±3.42 and 47.48±3.42 mg·100 g^{-1} in dry matter (DM) respectively. During current research it was found, that the content of vitamin B_1 and B_2 in cranberries was similar. The higher vitamin E content was found in wild and cranberry cultivars 'Ben Lear' and 'Pilgrim', ie., 1.56 mg 100g^{-1}, 1.50 mg 100g^{-1} and 1.58 mg 100g^{-1} in DM respectively. Higher essential amino acid content was found in wild and cranberry cultivars 'Bergman', 'Pilgrim' and 'Early Black' 1.94 g 100g^{-1}, 2.06 g 100g^{-1}, 1.83 g 100g^{-1} and 2.23 g 100g^{-1} in DM respectively.

Key words: amino acids, vitamins, cranberry cultivars

Introduction

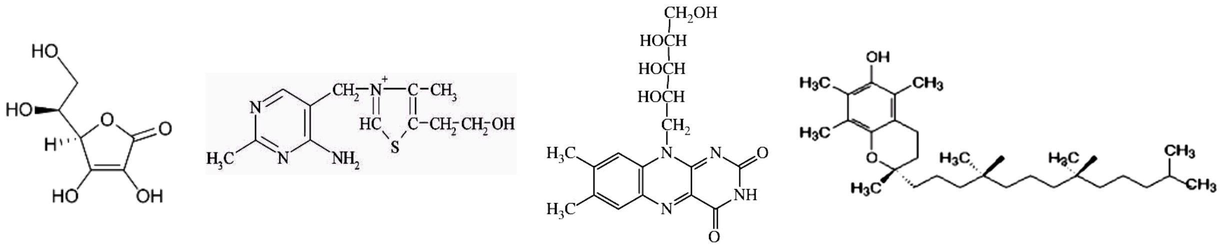
Berries contain a diverse array of nutrients with recognized biological activities that promote or contribute to health; different kinds of anti-oxidant compounds, including flavonoids, phenolics, carotenoids and vitamins, which are all considered beneficial to human health, for decreasing the risk of degenerative diseases by reduction of oxidative stress, and for the inhibition of macromolecular oxidation (Heber, 2004; Rangkadilok et al., 2007).

Vitamins are a diverse group of compounds, both chemically and analytically, because they comprise a range of biomolecules whose common properties reside solely in the fact that they are essential dietary components. These compounds are needed in relatively small amounts to sustain life and good health (Bates, 1999).

Vitamin C (Figure 1) is the most important vitamin for human nutrition that is supplied by fruits and vegetables. L-Ascorbic acid (AA) is the main biologically active form of vitamin C. AA is reversibly oxidised to form L-dehydroascorbic acid (DHA), which also exhibits biological activity. Since DHA can be easily converted into AA in the human body it is important to measure both AA and DHA in fruits to know vitamin C activity (Davey et al., 2000; Deutsch, 2000). AA is widely distributed in plant cells where plays many crucial roles in growth and metabolism. As a potent antioxidant, AA has the capacity to eliminate several different reactive oxygen species, keeps the membrane-bound antioxidant ά-tocopherol in the reduced state, acts as a cofactor maintaining the activity of a number of enzymes (by keeping metal ions in the reduced state), appears to be the substrate for oxalate and tartrate biosynthesis and has role in stress resistance (Arrigoni and De Tullio, 2002; Klein and Kurilich, 2000).

In foodstuffs, the vitamins B_1, B_2 (Figure 1) and B_6 may be present in free (thiamine, riboflavin, pyridoxol, pyridoxal and pyridoxamine) and phosphorylated forms (essentially thiamine pyrophosphate, riboflavin-5'-phosphate (FMN), riboflavin-5'-adenosyldiphosphate (FAD) and pyridoxal phosphate (Ndaw et al., 2000).

Thiamin (Figure 1) is one of the least stable of the water-soluble vitamins when the pH of the matrix approaches neutrality. Vitamin is characterized by a pyrimidine ring linked by a methylene bridge to the 3-nitrogen atom in a substituted thiazole; the vitamin is highly susceptible to losses during thermal processing. Riboflavin (Figure 1) is stable to heat and oxidation if protected from light; thus, most food processing operations have little effect on riboflavin content (Eitenmiller et al., 2008).



(a) (b) (c) (d)

Figure 1. Ascorbic acid (reduced form) (a), free thiamine base (b), riboflavin (c), α-tocopherol (d) (Eitenmiller et al., 2008)

Vitamin E (Figure 1), also known as ά-tocopherol, is an important vitamin found largely in plant materials. Its complex biological functions may include anti sterility, an antioxidant role. The beneficial role of vitamin E in preventing degenerative physiological process and ageing is still being investigated (Tütem et al., 1997). Biologically, vitamin E functions as the primary antioxidant and as a peroxy free radical scavenger. It is the primary, lipid-soluble, chain-breaking antioxidant that combines actions with other lipid- and water-soluble antioxidants to provide cells with an efficient defense against free radical damage. Free radicals are chemical species capable of independent existence that contain one or more unpaired electrons (Eitenmiller et al., 2008).

Amino acids are important of these is concerned with assessing the nutritional value of food and drink products. The monitoring of fermentation and correlated flavour trends in the development of foods and drinks, and the assessing of levels of amino acid fortification also require these compounds to be analyzed (Callejón et al., 2010). For example, Lysine (Lys) is an essential amino acid in humans because there is no Lys biosynthetic cellular machinery (Seminotti et al., 2008); the threonine (Thr) dehydrogenise catalyzes the NAD^{+}-dependent (nicotinamide adenine dinucleotide) oxidation of L-threonine to 2-amino-3-ketobutyrate (or 2-amino-3-oxobutanoate (Chen et al., 1995) and the Methionine (Met) is an essential amino acid with an important role in biological methylation reactions. It constitutes the main supply of sulphur in the diet, preventing disorders in hair, skin or nails. Moreover, it helps to reduce cholesterol levels by increasing the lecithin production in liver, being also a natural chelating agent for heavy metals (Agüí et al., 2004).

The current research focuses on the evaluation of vitamins and amino acid content in wild and cultivated cranberries grown in Latvia.

Materials and Methods

The research was accomplished on fresh Latvia wild growing (*Vaccinium oxycoccus* L.) and cultivated cranberries (*Vaccinium macrocarpon* Ait.) harvested in Kurzeme region in the first part of October 2010: wild cranberries and cranberry cultivars ‘Stevens’, ‘Bergman’, ‘Ben Lear’, ‘Pilgrim’ and ‘Early Black’ (the moisture content of berries is summarized in Table 1).

The following quality parameters of cranberries were controlled using standard methods: vitamin E by AOAC 971.30, vitamin B_1 by AOAC 986.27, vitamin B_2 by AOAC 970.65, vitamin C by LVSEN 14130:2003, amino acids except tryptophan by ion exchange method (Šťavíková and Htka, 2008), tryptophan by spectrophotometric method (Ren et al., 2007).

Table 1

Moisture content of fresh cranberries

No.	Cranberry cultivar	Moisture content, %
1	**Wild**	85.91±2.40
2	**‘Stevens’**	86.52±3.12
3	**‘Bergman’**	88.19±2.85
4	**‘Ben Lear’**	87.36±2.91
5	**‘Pilgrim’**	87.36±2.12
6	**‘Early Black’**	86.31±3.73

Data are expressed as mean ± standard deviation; for the mathematical data processing *Sheffe* test was used and p-value at 0.05 was used to determine the significant differences. Experiments were carried out in triplicate.

Results and Discussion

Mainly fresh cranberries contain 13.3 mg $100g^{-1}$ of Vitamin C (Nutritional value..., 2011), it is 103.34 mg $100g^{-1}$ in DM; however, in Latvia grown cranberries contain lower Vitamin C content (Table 2), what mainly could be explained with climatic conditions. In the present research after acquired data mathematical processing it was established, that there is substantial difference in Vitamin C content in analysed wild and cultivated cranberries (p=0.001) grown in Latvia. Similar Vitamin C content, i.e., differences was not substantial (p=0.511), was found in cranberry cultivars ‘Stevens’, ‘Ben Lear’ and ‘Bergman’, it was ~1.2 times or by 21% higher comparing to Vitamin C content in wild cranberries – 46.98±2.83 mg $100g^{-1}$ in DM, what is substantially (p=0.001). The lowest Vitamin C content was detected in wild cranberries (Table 2): it was by 10% less (substantially, p=0.001) than vitamin C content in cranberry cultivars ‘Pilgrim’ and by 1% less (not substantially, p=0.053) than vitamin C content in cranberry cultivar ‘Early Black’ (Table 2). Else, there is found substantially difference (p=0.001) in vitamin C content in cranberry cultivars ‘Pilgrim’ and ‘Early Black’. Vitamin C content in berries mainly depend on variety individuality, weather conditions during growing period, age of plant, ripening level, fertilizers presence and other factors.

Table 2

Vitamin C content in dry matter of fresh cranberries

No.	Cranberry cultivar	Content of Vitamin C, $mg \cdot 100\ g^{-1}$
1	Wild	46.98±2.83
2	‘Stevens’	57.05±3.12
3	‘Bergman’	56.56±1.45
4	‘Ben Lear’	57.83±3.22
5	‘Pilgrim’	51.89±2.11
6	‘Early Black’	47.48±2.75

The Recommended Dietary Allowances (RDA) of Vitamin C are 75 to 90 mg d^{-1} for adult women and men, respectively (Eitenmiller et al., 2008). Therefore, it will be necessary to use in nutrition about ~1.0 kg d^{-1} of fresh cranberries to reach RDA. It is known, that many berries contain concentrations of food folate, B vitamins such as niacin, tocopherols, and vitamin K, which are important for human health. Therefore it was very important to analyse B group and vitamin E content in cranberries. As the literature data demonstrate, the content of Thiamin in fresh cranberries is 0.012 mg 100 g^{-1}, Vitamin E − 1.2 mg 100 g^{-1} (Nutritional value..., 2011). By Eitenmiller (2008) RDA as set by the Institute of Medicine in the Dietary Reference Intake

(DRI) for thiamin (Vitamin B_1) are 1.2 and 1.1 mg d^{-1} for adult men and women, respectively. Our experiments show (Figure 2), that cranberries will be not as a source of thiamin B_1 in diet, because 100 g of fresh cranberries contains ~0.03 mg of Vitamin B_1, i.e., ~3% of RDA. However, positively is to observe, that Vitamin B_1 was detected in cranberries. After mathematical data processing it was found, that there is no relevant differences (p=0.051, p=0.833, p=0.057) between wild, 'Stevens' and 'Bergman' cranberry cultivars and between 'Ben Lear', 'Pilgrim' and 'Early Black' (p=0.051, p=0.290, p=0.292) in Vitamin B_1 content. However, relevant difference in Vitamin B_1 content was found between wild, 'Stevens', 'Bergman' and 'Ben Lear', 'Pilgrim' and 'Early black' cranberry cultivars (p=0.001). It was ascertained, that in cranberry cultivars 'Ben Lear', 'Pilgrim' and 'Early Black' Vitamin B_1 content was equally by 50% less than Vitamin B_1 content in wild, 'Stevens' and 'Bergman' cranberry cultivars, what mainly could be explained with berries individuality and Vitamin B_1 formation intense in berries during growing. The RDA for riboflavin (Vitamin B_2) range from 0.5 mg d^{-1} for children (1–3 years) to 1.6 mg d^{-1} for males and females. The RDI used for the nutritional label declaration is 1.7 mg (Eitenmiller et al., 2008). Therefore, 100 g of fresh cranberries contains ~0.04 mg of Vitamin B_2, i.e., ~3% of RDA. There is found substantial difference (p=0.001) in Vitamin B_2 content in analyzed cranberries. The content of Vitamin B_2 was significantly higher (p=0.001) in 'Bergman' and 'Ben Lear' cranberry cultivars by 74% and 61% respectively comparing to wild cranberries (Figure 2), what mainly could be explained with variety individuality and fertilizers presence during berries growing. However, there is no found significant difference in analyzed vitamin content in 'Stevens' (p=0.833), 'Ben Lear' (p=0.864) and 'Pilgrim' (p=0.052) cranberry cultivars comparing to wild berries.

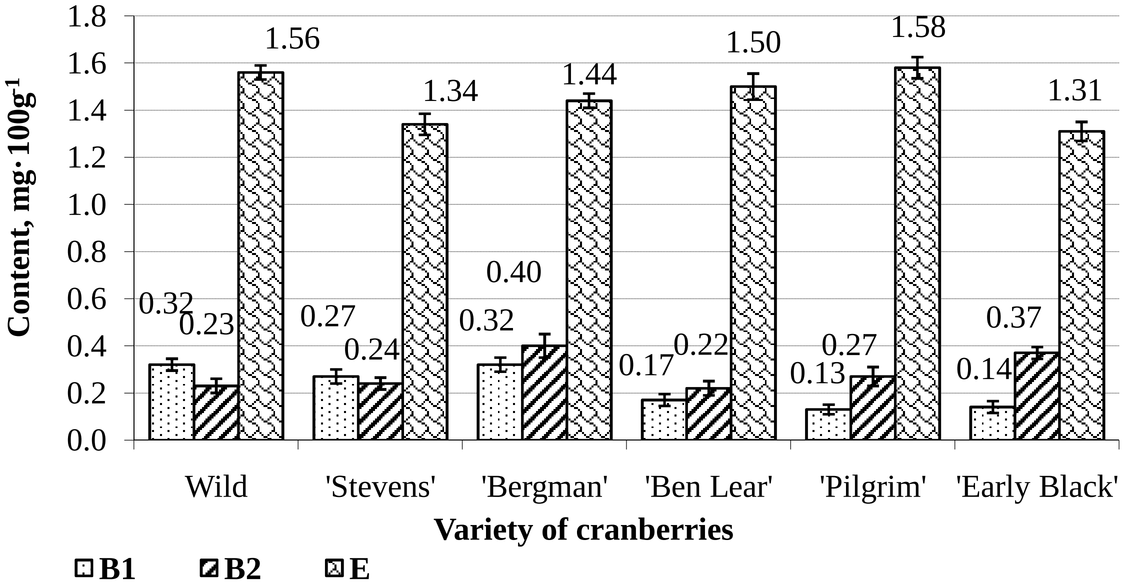


Figure 2. B_1, B_2 and E vitamin content in dry matter of fresh cranberries

By Eitenmiller (2008) Estimated Average Requirement (EAR) and Reference Daily Intake (RDA) are 12 mg and 15 mg of Vitamin E (α-T) per day, respectively. The upper intake level (UL) value includes all forms of α-T from supplemental intake of all-*rac*-α-T. The UL is 1000·mg d^1. Therefore, 100 g of fresh cranberries contains ~0.2 mg of Vitamin E, i.e., ~1.3% of RDA. In present research it was found, that there is no significant difference in vitamin E content between wild and 'Pilgrim' (p=0.911), wild and 'Ben Lear' (p=0.575) cranberry cultivar However, the content of Vitamin E is significantly (p=0.04 and p=0.02) lower in cranberry cultivars 'Stevens' and 'Early Black' by 14% and 16% respectively comparing to wild cranberries.

Higher total irreplaceable amino acid content was found in wild and cranberry cultivars 'Bergman', 'Pilgrim' and 'Early Black' − 1.94 g 100g^{-1}, 2.06 g·100 g^{-1} in DM, 1.83 g 100 g^{-1} and 2.23 g 100 g^{-1} in DM respectively, lower − in 'Stevens' and 'Ben Lear' – 1.46 g 100 g^{-1} and 1.12 g 100 g^{-1} in DM respectively. Thereby, significant difference (p=0.001) was found in total essential amino acid content in 'Stevens' (by 25% less), 'Ben Lear' (by 42% less) and 'Early Black' (by 15% higher) cranberry cultivars comparing to wild grown berries.

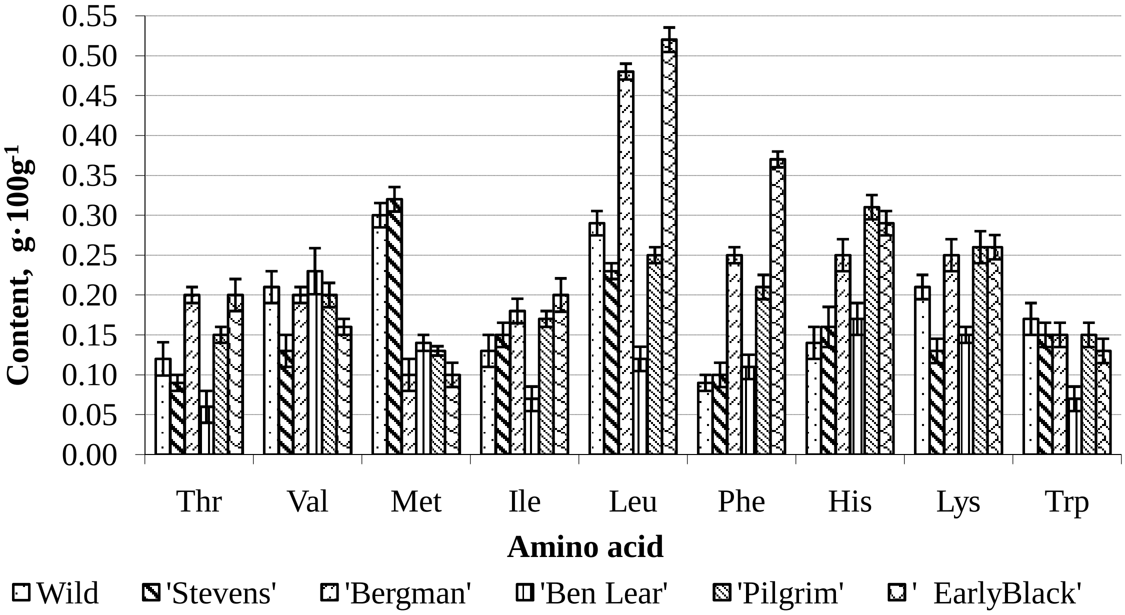


Figure 3. Essential amino acid profile in dry matter of fresh cranberries

In the present experiments it was established, that the content of threonine, tryptophan, isoleucine and histidine in berries was low. However, equally the content of leucine is by 45%, lysine by 15%, valine and phenylalanine by 14% was higher comparing to threonine, tryptophan, isoleucine and histidine content in cranberries. By Amino Labs (2011) RDA for essential amino acids range from ~4 g d^{-1} for females to ~5 g d^{-1} for males. Therefore 100 g of fresh cranberries contains ~0.1 g of essential amino acids, i.e., ~3% of RDA.

Conclusions

1. Similar Vitamin C content was found in cranberry cultivars 'Stevens', 'Ben Lear' and 'Bergman', it was by 21% higher comparing to Vitamin C content in wild cranberries – 46.98±2.83 mg 100 g^{-1} in dry matter; the lowest Vitamin C content was detected in wild cranberries.
2. There is no relevant differences between wild, 'Stevens' and 'Bergman' cranberry cultivars and between 'Ben Lear', 'Pilgrim' and 'Early Black' in Vitamin B_1 content. In cranberry cultivars 'Ben Lear', 'Pilgrim' and 'Early Black' Vitamin B_1 content was equally by 50% less than Vitamin B_1 content in wild, 'Stevens' and 'Bergman' cranberry cultivars.
3. There is found substantial difference in Vitamin B_2 content in analyzed cranberries: the content of Vitamin B_2 was significantly higher in 'Bergman' and 'Ben Lear' cranberry cultivars by 74% and 61% respectively comparing to wild cranberries.
4. There is no significant difference in vitamin E content between wild and 'Pilgrim', wild and 'Ben Lear' cranberry cultivars; the content of Vitamin E is significantly lower in cranberry cultivars 'Stevens' and 'Early Black' by 14% and 16% respectively comparing to wild cranberries.

5. Significant difference was found in total essential amino acid content in 'Stevens' (by 25% less), 'Ben Lear' (by 42% less) and 'Early Black' (by 15% higher) cranberry cultivars comparing to wild grown berries.
6. As results of current research demonstrate fresh cranberries could be source of Vitamin C in diet but not of Vitamins B_1, B_2, E and essential amino acids.

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References

1. Agüí L., Manso J., Yáñez-Sedeño P., Pingarrón J.M. (2004) Colloidal-gold cysteamine-modified carbon paste electrodes as suitable electrode materials for the electrochemical determination of sulphur-containing compounds Application to the determination of methionine. *Talanta*, 64, pp. 1041–1047.
2. Amino labs. 2011. Source: http://www.aminolabs.net/; recourse used on 03.03.2011.
3. Arrigoni O., De Tullio M.C. (2002) Ascorbic acid: Much more than just an antioxidant. *Biochimica et Biophysica Acta*, 1569, pp. 1–9.
4. Bates C.J. *Encyclopaedia of Analytical Chemistry* (1999) Meyers, R.A. (ed.) John Wiley, Chichester, pp. 4278–4318.
5. Callejón R.M., Trncoso A.M., Morales M.L. (2010) Determination of amino acids in grape-derived products: A review. *Talanta*, 81, pp. 1143–1152.
6. Chen Yen-Wen., Dekker E.E., Somerville R.L. (1995) Functional analysis of E.*coli* threonine dehydroginase by means of mutant isolation and characterization. *Biochimica et Biophysica Acta,* 1253, pp. 208–214.
7. Davey M.V., Van Montagu M., Inze D., Sanmartin M., Kanellis A., Smirnoff N., Benzie I.J.J., Strain J.J., Favell D., Fletcher J. (2000) Plant L-ascorbic acid: chemistry, function, metabolism, bioavailability and effects of processing. *Science of Food and Agriculture,* 80, pp. 825–860.
8. Deutsch J.C. (2000) Dehydroascorbic acid. *Cromatography A*, 881, pp. 299–307.
9. Eitenmiller R.R., Ye L., Landen Jr W.O. *Vitamin analysis for the health and food sciences.* (2008) Second edition, CRC Press, 627 p.
10. Heber D. (2004) Vegetables, fruits and phytoestrogens in the prevention of diseases. *Postgraduate Medicine*, 50, pp. 145−149.
11. Klein B.P., Kurilich A.C. (2000) Processing effects on dietary antioxidants from plant foods. *HortScience*, 35(4), pp. 580–584.
12. Ndaw S., Bergaentzlé M., Aoudé-Werner D., Hasselmann C. (2000) Extraction procedures for the liquid chromatographic determination of thiamine, riboflavin and vitamin B_6 in foodstuffs. *Food Chemistry*, 71, pp. 129–138.
13. Nutritional Value of Cranberries, raw. 2011. Source: http://www.happyjuicer.com /Nutrition/cranberries.aspx; recourse used on 25.03.2011.
14. Rangkadilok N., Sitthimonchai S., Worasuttayangkurn L., Mahidol C., Ruchirawat M., Satayavivad J. (2007) Evaluation of free radical scavenging and antityrosinase activities of standardized logan extract. *Food and Chemical Toxicology*, 45, pp. 328–336.
15. Ren J., Zhao M., Wang J., Cui C., Yang B. (2007) Spectrophotometric Method for Determination of Tryptophan in Protein Hydrolysates. *Food Technology and Biotechnology*, 45 (4), pp. 360–366.
16. Seminotti B., Leipnitz G., Amaral U.A., F ernandez G.C., Bortoli de Silva L., Tonin M.A., Vargas R.C., Wajner M. (2008) Lysine induces lipid and protein damage and decreases reduced glutathione concentrations in brain of young rats. *Developmental Neuroscience,* 26, pp. 693–698.
17. Šťavíková L., Htka M. (2008) The impact of fermentation process on amino acid profile of Grüner Veltliner white wine. *Chemické listy,* 102, pp. 800−802.
18. Tütem E., Apak R., Günaydi E., Sözgen K. (1997) Spectrophotometric determination of vitamin E (α-tocopherol) using copper – neocuproine reagent. *Talanta,* 44, pp. 249–255.