Croat. J. Food Sci. Technol. (2013) 5 (1) 29-33

The physico-chemical properties of strawberry tree (*Arbutus unedo* L.) fruits

R. Vidrih[*1], J. Hribar[1], Ž. Prgomet[2], N. Poklar Ulrih[1]

[1]*Department of Food Science and Technology, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, SI-1111 Ljubljana, Slovenia*
[2]*Collegium Fluminense, Trpimirova 2, HR-51000 Rijeka, Croatia*

professional paper

Summary

The physico-chemical properties of ripe fruits of strawberry tree (*Arbutus unedo* L.) were determined. The water content, ash, crude fat, proteins, total phenols, sugar, and the content of vitamin C were determined in ripe strawberry tree fruits. Fruits contain 46.7 % of water, 23.5 % of soluble solids, 0.48 % of ash, 118.61 mg/100 g of potassium, 20.63 mg/100 g of sodium, 36.05 mg/100 g of calcium, 9.66 mg/100 g of magnesium, 1.29 mg/100 g of iron, 19.99 mg/100 g of phosphorus, 0.45 mg/100 g of zinc, < 0.99 mg/100 g of manganese, < 0.99 mg/100 g of chromium, < 0.10 mg/100 g of nickel, < 1.32 mg/100 g of lead and < 0.10 mg/100 g of cadmium. Among nutritionally important components found in fruits were: total fat (0.43 %), proteins (0.82 %), fibres (18.5 g/100 g) of which 14.3 g/100g was insoluble and 4.19 g/100 g was soluble fibre, titratable acids (5.1 mg/100 g), glucose (6.2 g/100 g) and fructose (17.2 g/100 g). Ripe fruits contained 271.5 mg/100 g vitamin C, of which 255.3 mg/ 100 g was L-ascorbic acid and 16.2 mg/100 g was dehydroascorbic acid.

Keywords: Arbutus unedo, ascorbic acid, minerals, fatty acids, total phenols, dietary fibre

Introduction

The strawberry tree (*Arbutus unedo* L.) is an evergreen shrub or tree that can occasionally reach 9 m in height. It grows wildly in Mediterranean basin from sea level to about 600 m above sea level (Ayaz et al., 2000). Its habitat is usually dry rocky slopes although it grows well in heavier clay and dry soils. Interestingly, Ruiz-Rodríguez et al. (2011) reports that strawberry tree is growing also in Ireland. With regard to north Mediterranean, strawberry tree is found in coastal regions of Slovenia and Croatia. Strawberry tree fruits are globular, orange-red in colour, rough up to 2 cm across. The Latin name 'unedo' means 'I eat only one fruit' suggesting that the fruit is not delicious or it is so delicious that a person only needs to eat one. Anyway it is a fruit that is not consumed very often; it can be enjoyed when eaten in moderate quantities. Mediterranean region is well known for the consumption of locally grown plants, either wild or semi-wild. In the past, many of those plants were consumed and made an important contribution to health because they contained higher amounts of bioactive compounds than cultivated species (Malheiro et al., 2012; Trichopoulou et al., 2000). Nowadays it is scientifically proven, that the 'Mediterranean diet' is healthy, although unfortunately some local foods have not yet been studied thoroughly (Oliveira et al., 2011a).

Fruits and leaves of the strawberry tree have been used to treat various cardiovascular diseases such as hypertension, thrombosis and atherosclerosis (Afkir et al., 2008; El Haouari et al., 2007; Malheiro et al., 2012; Ziyyat et al., 2002). Also, antiseptic, diuretic and laxative effects have been reported (Karikas, 1993). Wine from strawberry tree fruits with 9 – 10 % of alcohol as well as brandy from wine are produced in Corsica and Sardinia. Bees collecting nectar from strawberry tree blossoms produce honey which is very aromatic and bitter in taste.

The aim of this study is to determine some chemical and nutritional properties of fresh strawberry tree fruits harvested in northern Mediterranean region.

Material and methods

Material

Fruits of strawberry tree (*Arbutus unedo* L.) were harvested near Vrsar, Croatia in November 2010. Sampling was carried out on 3 trees growing wildly. Approximately 3 kg of fruits of uniform ripeness (red colour) were harvested from each tree and transferred to laboratory at the day of harvest and stored overnight at + 4 °C. Analyses were carried out next day.

*Corresponding author: rajko.vidrih@bf.uni-lj.si

Determination of ascorbic-acid content

Ascorbic-acid content was determined according to the method described by de Quirós et al. (2009). 10 g of strawberry fruit was homogenised in 10 mL stabilising solution (2% [w/v] metaphosphoric acid). The analyses were performed on an HP1100 HPLC system (Hewlett-Packard) equipped with an HP1100 quaternary pump, an HP1100 degassing device, a 20-µl injection loop (Rheodyne, Cotati, CA) and an HP1100 UV-detector set at 245 nm. The HPLC system was controlled by a personal computer running Agilent ChemStation software for LC and LC/MS systems.

Determination of fatty acid composition

Fatty acids were determined as methyl esters after trans esterification of mesocarp together with seeds according to AOAC Official Methods 969.33 by gas chromatography on HP 5890 Hewlett-Packard gas chromatograph, series II instrument (Hewlett Packard Corp. Palo Alto. U.S.A.), equipped with a fused silica capillary column (Supelco; SP 2380 (30 m × 0.25 mm and film thickness 0.20 µm)). The stationary phase was Poly(90% biscyanopropyl/10% cyanopropylphenyl siloxane). The carrier gas was helium at 1 cm^3/min. The internal standard was heptadecanoic acid. The column temperature was programmed at 150 °C to 210 °C at 5 °C/min. Injector and flame - ionization detector temperatures were set at 220 °C and 250 °C, respectively. The injection volume was 1 µl. Identification was achieved by comparing the retention times for fatty acids methyl esters of investigated samples (mesocarp together with seeds) to the retention times of fatty acid methyl esters standards (FAME Mix rapeseed oil, Sigma-Aldrich, St.Louis, USA). The results were given as the weight percentage of total fatty acids. The analysis was carried out in duplicate. The standard error of determination was between 0.01 and 0.25 %.

Determination of total nitrogen

Content of total nitrogen was determined according to the method described by Hach et al. (1987).

Determination of total phenols

The total phenolic content of strawberry fruits was determined spectrophotometrically at 765 nm following the Folin-Ciocalteu method as described by Singleton et al. (1999). Supernatant from the mixture of fruits/metaphosphoric acid as described for ascorbic acid determination was used for the determination of total phenolics. A standard calibration curve was plotted using gallic acid (Merck, Germany) in the concentration range 1–500 mg/L. The results are expressed as milligrams of gallic acid equivalents per 100 g of fruit.

Soluble solids assay

Soluble solids were measured by means of a hand refractometer (Atago).

Determination of water

Water was determined according to method AOAC 950.46.

Determination of ash

Ash was determined according to method AOAC, 920.153.

Determination of dietary fibres

Dietary fibres were determined according to the method AOAC, 985.29.

Determination of minerals

Minerals were determined according to method described by Genccelep et al. (2009). Samples were digested in an acid solution of HNO_3 and analysed on an atomic absorption spectrophotometer Perkin – Elmer 1100 B (USA). Phosphorus content was determined using molybdovanadate method AOAC 986.08.

Determination of sugars

A HPLC system (Maxi Star, Knauer (Germany) equipped with a pump system, a refractive index detector (RI DETECTOR K-2301, Knauer, Germany) for sugar analysis.Sugars were analyzed onto an Aminex HPX-87H column. The analytical conditions used were as follows: flow 0.6 mL/min, eluent was 0.004 M H_2SO_4, injection volume was 20 µl.

Determination of organic acids

Organic acids were analysed according to the method (AOAC 942.15, 2005). Results are expressed as g of malic acid/100 g fruit.

Results and discussion

Table 1. Content of water, proteins, ash, total fat, total phenols, sugars, dietary fibers, ascorbic acid, minerals and fatty acids in fruits of strawberry tree

Water (%) f.w.	46.66 ± 3.88
Proteins (g/100 g f.w.)	0.82±0.02
Ash (g/100 g f.w.)	0.48±0.02
Total fat (g/100 g f.w.)	0.43±0.06
Total phenols (g/100 g f.w.)	0.59 ± 0.01
Soluble solids (% Brix)	21.05 ± 0.07
Titratable acidity (g malic acid/100 g f.w.)	0.51±0.01
Glucose (g/100 g)	5.27±0.33
Fructose (g/100 g)	16.62±0.50
Unsoluble dietary fibres (g/100 g f.w.)	14.3±0.92
Soluble dietary fibres (g/100 g f.w.)	4.19±0.67
Total dietary fibres (g/100 g f.w.)	18.49±0.56
Ascorbic acid mg/100 g f.w.	255.29±7.86
Dehydro ascorbic acid mg/100 g f.w.	16.17±5.18
Total ascorbic acid mg/100 g f.w.	271.46±3.01
K (mg/100 g f.w.)	118.61±10.79
Na (mg/100 g f.w.)	20.63±1.64
Ca (mg/100 g f.w.)	36.05±7.08
Mg (mg/100 g f.w.)	9.66±1.28
Fe (mg/100 g f.w.)	1.29±0.06
P (mg/100 g f.w.)	19.99±2.77
Zn (mg/100 g f.w.)	0.45 ± 0.10
Mn (mg/100 g f.w.)	< 0.99
Cr (mg/100 g f.w.)	< 0.99
Ni (mg/100 g f.w.)	< 0.10
Pb (mg/100 g f.w.)	< 1.32
Cd (mg/100 g f.w.)	< 0.10
Palmitic (C16:0) (mg/100 g f.w.)	50.0±1.0
%	19.0 ± 1.8
Stearic (C18:0) (mg/100 g f.w.)	traces
%	traces
Oleic (C18:1) (mg/100 g f.w.)	39.9±9.2
%	14.9 ± 1.8
Linolic (C18:2) (mg/100 g f.w.)	92.1±6.6
%	34.8 ± 2.4
Linolenic (C18:3) (mg/100 g f.w.)	83.5±16.3
%	31.3 ± 2.3

As seen in Table 1, fruits of strawberry tree contain 46.66 % of water, 0.82 g/100 g of proteins, 0.48 g/100 g of ash, 0.43 g/100 g of total fat and 0.59 g/100 g of total phenols. In comparison to our results, Ozcan and Haciseferogullari (2007) found higher content of water (53.72 %). Water content depends on pedoclimatic conditions and harvest date and usually varies from year to year. In their study, Ruiz-Rodríguez et al. (2011) found water content in the range from 46 to 53 % depending on location and year of production. Proteins represented minor components, their content amounting to 0.82 g/100 g. Ruiz-Rodríguez et al. (2011) reported their concentration to range from 0.58 to 1.19 g/100 g, while Seidemann (1995) determined proteins in the range from 0.8 to 1.0 g/100 g. On the other hand, Ozcan and Haciseferogullari (2007) found a much higher content of proteins, 3.36 %. Strawberry tree fruit contain 0.43 g/100 g of total fat which is in a range of normal fluctuations, 0.30 - 0.78 g/100 g, reported by Ruiz-Rodríguez et al. (2011). Ruiz-Rodríguez et al. (2011) in their study determined total phenols in range from 951 to 1973 mg/100 g f.w., which is more than in our case. Some authors (Alarcao-E-Silva et al., 2001; Ayaz et al., 2000) found total phenols expressed as mg catechin/g dry weight in range from 10.7 to 15.5 mg/g dry weight, their content being related to maturity stage. Similar results were reported by Oliveira et al. (2011b) and Oliveira et al. (2011c), indicating that content of total phenols fluctuate during ripening and the highest amount being found in an intermediate stage of maturity.

Mesocarp contains 21.5 % Brix of soluble solids, 0.51 g/100 g titratable acids, 5.27 g/100 g of glucose and 16.62 g/100 g of fructose (Table 1). Ruiz-Rodríguez et al. (2011) found 6.50 g/100 g of glucose, 12.34 g/100 g of fructose and 0.34 g/100 g of sucrose. Contents of glucose and fructose in our study are in accordance with results of Ruiz-Rodríguez et al. (2011), while we found sucrose content below detection limit. According to results of Ozcan and Haciseferogullari (2007) fruits contain 0.4 g/100 g of titratable acidity. Our results are in accordance with their study.

Strawberry tree fruits are a good source of dietary fibres. Fruits mesocarp contains 14.3 g/100 g of insoluble dietary fibres, 4.19 g/100 g of soluble dietary fibres and 18.49 g/100 g of total dietary fibres (Table 1). In their research, Ruiz-Rodríguez et al. (2011) found lower values, 2.93 g/100 g soluble fibres, 7.86 g/100 g of insoluble fibres and 10.83 g/100 g of total fibres. With respect to dietary fibres, Ozcan and Haciseferogullari (2007) found 6.4 g/100 g of cellulose.

Strawberry tree fruits are a very good source of ascorbic acid. As seen in Table 1, fruits contain 255.29 mg/100 g of ascorbic acid and 16.17 mg/100 g of dehydroascorbic acid. Our results of ascorbic acid are higher than that of Ruiz-Rodríguez et al. (2011) who found 111.8 mg/100 g of ascorbic acid and 26.7 mg/100 g of dehydroascorbic acid. According to Saxholt and Moller (2008) total ascorbic acid content amount was 270 mg/100 g f.w. Due to its high content of ascorbic acid, it can be stated that vitamin C is the most interesting contributor to nutrient intake of strawberry tree fruit.

Linolic acid was the prevailing fatty acid in mesocarp (92.1 mg/100 g), followed by linolenic (83.5 mg/100 g), palmitic (50.0 mg/100 g) and oleic (39.9 mg/100 g) acid. As far as fatty acid composition is concerned, the following ratios of individual fatty acids expressed as g /100 g all fatty acids were found: linolic (34.8 %), linolenic (31.3 2.3 %), palmitic (19.0 1.8 %) and oleic (14.9 1.8 %), (Table 1). Similar results were found by Oliveira et al. (2011b). They found stearic acid approximately 2 % of total fatty acids, while their data showed the linolenic acid as prevalent followed by linolic acid. The order of other fatty acids was the same as ours; they also found some minor fatty acids in trace levels. Polyunsaturated fatty acids represent the major fraction (66.1 %) with a highly favourable ratio n3/n6 i.e. (0.09). Oliveira et al. (2011b) found an increase in the content of α-linoleic acid during maturation and a concomitant decrease of linolic and oleic acid.

Potassium was the most abundant element found in mesocarp (118.61 mg/100 g), followed by calcium (36.05 mg/100 g), sodium (20.63 mg/100 g), phosphorus (19.99 mg/100 g) and magnesium (9.66 mg/100 g) (Table 1).

Regarding microelements, mesocarp contains iron (1.29 mg/100 g) and zinc (0.45 mg/100 g), while the concentrations of Mn, Cr, Ni, Pb and Cd were below corresponding detection limits (Table 1). Other authors, Ruiz-Rodríguez et al. (2011), found more potassium (177 mg/100 g), less sodium (7.52 mg/100 g), twice as much calcium and magnesium, less iron (0.885 mg/100 g) and a similar amount of Zn.

Conclusions

From the nutritional point of view, strawberry fruits are very interesting even though they have a reputation not to be delicious at all.

Strawberry tree fruits are a very rich source of vitamin C; its content exceeding 200 mg/100 g. Only a few fruit or vegetable species contain more vitamin C. With regard to antioxidants, fruits of strawberry tree also contain other vitamins or provitamins that were not determined in this work. Fruits of strawberry tree contain an average amount of total polyphenols as compared to other fruit species. Beside antioxidants, strawberry tree fruit is a good source of another nutritionally important constituent, dietary fibre. Most other fruits contain around 10 g of dietary fibre/100 g, while strawberry fruits contain 18 g/100 g total dietary fibre.

Among minor nutritionally important components, strawberry fruit contains an amount of potassium comparable to other fruits.

In general, our results are in good agreement with results of other works, although we found exceptions like the content of vitamin C, dietary fibres and fatty acids. These differences could be attributed to pedoclimatic conditions, genetic factors, as well to the methods of analyses employed.

Literature

AOAC 985.29, *Total Dietary fiber in Foods-Enzymatic-Gravimetric Method.* Official methods of analysis of AOAC International (16th ed.). Gaithersburg, Maryland: AOAC International.

AOAC 920.153, *Ash of meat.* Official methods of analysis of AOAC International (16th ed.). Gaithersburg Maryland: AOAC International.

AOAC 950.46, *Moisture in meat.* Official methods of analysis of AOAC International (16th ed.). Gaithersburg Maryland: AOAC International.

AOAC 991.36, *Fat (crude) in meat and meat products.* Official methods of analysis of AOAC International (16th ed.). Gaithersburg Maryland: AOAC International.

AOAC, 942.15, *Acidity (Titratable) of fruit products.* Official methods of analysis of AOAC International (16th ed.). Gaithersburg Maryland: AOAC International.

AOAC 986.08, *Minerals in animal feed and pet food*. 1999. Official methods of analysis of AOAC International (16th ed.). Gaithersburg Maryland: AOAC International.

Afkir, S., Nguelefack, T.B., Aziz, M., Zoheir, J. Cuisinaud, G., Bnouham, M., Mekhfi, H., Legssyer, A., Lahlou, S. Ziyyat, A., (2008): *Arbutus unedo* prevents cardiovascular and morphological alterations in L-NAME-induced hypertensive rats: Part I: Cardiovascular and renal hemodynamic effects of *Arbutus unedo* in L-NAME-induced hypertensive rats. *J. Ethnopharmacol.* 116 (2), 288-295.

Alarcao-E-Silva, M., Leitao, A.E.B., Azinheira, H.G. Leitao, M.C.A. (2001): The *Arbutus* berry: Studies on its color and chemical characteristics at two mature stages. *J. Food Compos. Anal.* 14 (1), 27-35.

Ayaz, F.A., Kucukislamoglu, M. Reunanen, M. (2000): Sugar, Non-volatile and Phenolic Acids Composition of Strawberry Tree (*Arbutus unedo* L. var.ellipsoidea) Fruits. *J. Food Compos. Anal.* 13 (2), 171-177.

de Quirós, A.R.-B., Fernández-Arias, M. López-Hernández, J. (2009): A screening method for the determination of ascorbic acid in fruit juices and soft drinks. *Food Chem.* 116 (2), 509-512.

El Haouari, M., López, J.J., Mekhfi, H., Rosado, J.A. Salido, G.M. (2007): Antiaggregant effects of *Arbutus unedo* extracts in human platelets. *J. ethnopharmacol.* 113 (2), 325-331.

Genccelep, H., Uzun, Y., Tuncturk, Y. Demirel, K. (2009): Determination of mineral contents of wild-grown edible mushrooms. *Food Chem.* 113 (4), 1033-1036.

Hach, C.C., Bowden, B.K., Kopelove, A.B. Brayton, S.V. (1987): More powerful peroxide kjeldahl digestion method. *J. - Assoc. Off. Anal. Chem.* 70, 783-787.

Karikas, G.A. (1993): Iridoids from *Arbutus unedo*. *Fitoterapia* 64 (2), 187.

Malheiro, R., Sá, O., Pereira, E., Aguiar, C., Baptista, P. Pereira, J.A. (2012): *Arbutus unedo* L. leaves as source of phytochemicals with bioactive properties. *Ind. Crops Prod.* 37 (1), 473-478.

Oliveira, I., Baptista, P., Bento, A. Pereira, J.A. (2011a): *Arbutus unedo* L. and its benefits on human health. *J. Food Nutr. Res.* 50 (2), 73-85.

Oliveira, I., Baptista, P., Malheiro, R., Casal, S., Bento, A. Pereira, J.A. (2011b): Influence of strawberry tree (*Arbutus unedo* L.) fruit ripening stage on chemical composition and antioxidant activity. *Food Res. Int.* 44 (5), 1401-1407.

Oliveira, I., de Pinho, P.G., Malheiro, R., Baptista, P. Pereira, J.A. (2011c): Volatile profile of *Arbutus unedo* L. fruits through ripening stage. *Food Chem.* 128 (3), 667-673.

Ozcan, M.M. Haciseferogullari, H. (2007): The strawberry (*Arbutus unedo* L.) fruits: Chemical composition, physical properties and mineral contents. *J. Food Eng.* 78 (3), 1022-1028.

Ruiz-Rodríguez, B.-M., Morales, P., Fernández-Ruiz, V., Sánchez-Mata, M.-C., Cámara, M., Díez-Marqués, C., Pardo-de-Santayana, M., Molina, M. Tardío, J. (2011): Valorization of wild strawberry-tree fruits (*Arbutus unedo* L.) through nutritional assessment and natural production data. *Food Res. Int.* 44 (5), 1244-1253.

Saxholt, E. Moller, A. 2008. Danish food composition databank.

Seidemann, J. (1995): Description of exotic fruits - arbutus (*Arbutus-unedo* L). *Dtsch. Lebensm.-Rundsch.* 91 (4), 110-113.

Singleton, V.L., Orthofer, R. Lamuela-Raventos, R.M. 1999. Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent, In: Packer, L. (Ed.), Oxidants and Antioxidants, Pt A, pp. 152-178.

Trichopoulou, A., Vasilopoulou, E., Hollman, P., Chamalides, C., Foufa, E., Kaloudis, T., Kromhout, D., Miskaki, P., Petrochilou, I., Poulima, E., Stafilakis, K. Theophilou, D. (2000): Nutritional composition and flavonoid content of edible wild greens and green pies: a potential rich source of antioxidant nutrients in the Mediterranean diet. *Food Chem.* 70 (3), 319-323.

Ziyyat, A., Mekhfi, H., Bnouham, M., Tahri, A., Legssyer, A., Hoerter, J. Fischmeister, R. (2002): *Arbutus unedo* induces endothelium-dependent relaxation of the isolated rat aorta. *Phytother. Res.* 16 (6), 572-575.

Received: May 24, 2013
Accepted: July 9, 2013