Journal of Food Composition and Analysis 45 (2016) 108–112

Contents lists available at ScienceDirect

Journal of Food Composition and Analysis

journal homepage: www.elsevier.com/locate/jfca

Original Research Article

The oxalate content of fruit and vegetable juices, nectars and drinks

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ARTICLE INFO

Article history:
Received 28 July 2015
Received in revised form 17 October 2015
Accepted 17 October 2015
Available online 20 October 2015

Keywords:
Oxalic acid
Calcium
Beverages
Fluid intake
Anti-nutrient
Diet
Urinary calculi
Urolithiasis
Food analysis
Food composition

ABSTRACT

Fruit and vegetable juices are recommended for the treatment of hypocitraturia in calcium oxalate stone disease as alternatives to drugs containing alkaline citrate. Since dietary oxalate can contribute considerably to urinary oxalate excretion, the oxalate content of vegetable and fruit juices, nectars and drinks was analyzed using a validated HPLC-enzyme-reactor method. The highest oxalate concentrations were found in rhubarb nectar (198.3 mg/100 ml) and beetroot juices (60.1–70.0 mg/100 ml). The oxalate levels of all other beverages were below 10 mg/100 ml. Interestingly, except for carrot juice, the oxalate content of juices containing vegetables from organic farming was higher than from conventional farming. The consumption of even 500 ml/d of certain vegetable juices can contribute to a considerable extent to the daily oxalate intake. Calcium oxalate stone formers should therefore pay attention not only to the oxalate content but also to the ingested amount of these beverages.

1. Introduction

Approximately 75% of all urinary stones mainly consist of calcium oxalate (Hesse and Siener, 1997). Hypocitraturia is a common metabolic abnormality, diagnosed in up to 60% of calcium oxalate stone formers (Siener et al., 2005). Fruit and vegetable juices are recommended for the treatment of hypocitraturia as alternatives to pharmacologic therapy in the form of alkaline citrate. Particularly citrus juices, such as orange, grapefruit and lemon, but also tomato juice are considered rich sources of citrate (Penniston et al., 2008; Yilmaz et al., 2008, 2010). Ingested citrate is absorbed in the intestine and nearly completely metabolized to bicarbonate, providing an alkali load, which in turn enhances urinary citrate excretion (Simpson, 1983).

Moreover, fruit and vegetable juices are considered a good source of bioactive compounds which have been associated with a number of beneficial effects on human health. The positive physiological effects of juice consumption may particularly be due to their content of different classes of phytochemicals including flavonoids, found e.g. in grapefruit, orange and apple, and carotenoids, e.g. in carrot and tomato juices, which exhibit, among others, anti-oxidative, anti-inflammatory and anti-carcinogenic properties (Watzl, 2008). A study conducted by Holoch and Tracy (2011) indicated a likely role of antioxidants in preventing stone formation.

However, plants and plant products are main sources of dietary oxalate (Noonan and Savage, 1999; Hönow and Hesse, 2002; Siener et al., 2006a,b; Nguyen and Savage, 2013). Secondary hyperoxaluria, resulting from high dietary intake or intestinal hyperabsorption of oxalate, is considered a primary risk factor in the pathogenesis of calcium oxalate stone disease. It has been suggested that dietary contribution to urinary oxalate excretion is up to 50% (Holmes et al., 2001). A high dietary intake of oxalate can significantly increase urinary oxalate excretion even in healthy individuals without disturbances in oxalate metabolism (Siener et al., 2013). Intestinal hyperabsorption of oxalate can considerably contribute to urinary oxalate excretion (Voss et al., 2006).

Furthermore, dietary oxalate reduces the absorption of calcium and magnesium and is expected to impair the bioavailability of a number of trace elements due to the formation of insoluble complexes (Kelsay and Prather, 1983; Heaney et al., 1988; Bohn et al., 2004).

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http://dx.doi.org/10.1016/j.jfca.2015.10.004
0889-1575/

Detailed knowledge of food oxalate content is therefore of essential importance for dietary treatment of recurrent calcium oxalate urolithiasis. Most fruits and vegetables in a typical Western diet, which have been analyzed so far, contained low to moderate concentrations of oxalate (Hönow and Hesse, 2002; Nguyen and Savage, 2013). Because comprehensive and reliable data on the oxalate content of fruit and vegetable juices are lacking, the purpose of the present study was to determine the soluble and total oxalate content of various types of fruit and vegetable juices, nectars and drinks.

2. Materials and methods

All fruit and vegetable juices, nectars and drinks were commercially produced and purchased from local establishments in Bonn, Germany. Samples were obtained shortly before analysis. The products are listed in Tables 1 and 2. All beverages were shaken prior to analysis.

2.1. Sample preparation

The measurement of total and soluble oxalates was performed following the method outlined by Hönow and Hesse (2002). For the extraction of the soluble oxalate content, each beverage sample was filtrated. The filtrates were acidified with 50 µl 2 N hydrochloric acid (p.a.; Merck, Darmstadt, Germany) to stabilize potentially contained ascorbic acid. Total oxalate content was determined in beverages, which left residues after filtration. For the analysis of the total oxalate content, 2 ml of the unfiltered sample of each beverage were suspended with 2 ml distilled water and 2 ml 2 N hydrochloric acid, homogenized, and filtrated. The filtrates were immediately analyzed by HPLC-enzyme-reactor method after dilution. For the determination of soluble and total oxalate contents, 10 µl of the filtrated solution were injected twice. The detection limit was 0.68 µM (0.06 mg) (Hönow and Hesse, 2002). All samples, including both oxalate extraction methodologies, were analyzed in duplicate. The oxalate content is presented as mg/100 ml fresh weight as this is how these products are consumed. The number of different products (n) is indicated in the tables.

2.2. HPLC-enzyme-reactor method

Analysis of filtrates was performed by a selective and sensitive HPLC-enzyme-reactor method (Hönow et al., 1997). This method combines enzymatic conversion of oxalate to hydrogen peroxide and its amperometric detection with the selectivity of a chromatographic separation. HPLC-system (Gynkotek Modell 300, Gina 50, Germering, Germany) consisted of an anion exchange column (AS4A-DIONEX, ThermoFisher Scientific, Waltham, Massachusetts), a mobile phase of an aqueous EDTA solution (2.0 g/l, adjusted to pH 5.0 with 0.3 mol/l NaOH; flow rate: 0.6 ml/min) (p.a.; Merck, Darmstadt, Germany), an enzyme reactor containing 5 units of immobilized oxalate oxidase (oxalate oxidase: E.C. 1.2.3.4.; Sigma Diagnostics, St. Louis, USA; carrier: VA Epoxy Biosynth, Riedel-de-Häen, Seelze, Germany), which oxidized oxalate to hydrogen peroxide and carbon dioxide. Resulting hydrogen peroxide was analyzed by an amperometric platinum detector (potential: +0.5 V; silver-silver chloride electrode; Gynkotek PED 300, Germering, Germany). Peaks were quantified via peak area and external calibration curves (Hönow et al., 1997). Typical chromatograms for oxalate standard and samples (apple juice) are included as Supplementary Figs. 1 and 2.

3. Results

The soluble and total oxalate contents of various types of fruit and vegetable juices, nectars and drinks are listed in Tables 1 and

Table 1
Oxalate content of vegetable juices, nectars and drinks (mg/100 ml).

	Kind of sample	Manufacturer		Soluble oxalate			Total oxalate	
			n	Mean	SD	*n*	Mean	SD
Vegetable juices								
Beetroot juice *Beta vulgaris*	100% juice	Grünfink	1	54.33	–	1	60.09	–
Beetroot juice *Beta vulgaris*	100% juice, organic[a]	Naturkind; Füllhorn; Schneekoppe	3	65.15	6.52	3	70.01	8.04
Carrot juice *Daucus carota*	100% juice	A. Dohrn & A. Timm; Grünfink	2	3.25	4.60	2	5.81	6.20
Carrot juice *Daucus carota*	100% juice, organic[a]	Hipp; Füllhorn	2	1.76	0.24	2	5.07	0.69
Sauerkraut juice *Brassica oleracea*	100% juice, organic[a]	Füllhorn; Naturkind	2	0.38	0.30		–	
Tomato juice *Lycopersicum esculentum*	100% juice	A&P; Drink	2	0.80	1.13	2	4.34	1.34
Tomato juice *Lycopersicum esculentum*	100% juice, organic[a]	Naturkind; Vita Verde	2	2.12	0.62	2	8.12	3.49
Multi-vegetable juice	100% juice (main constituents: tomato, carrot, celery, lemon)	A&P; Drink	2	0.76	1.06	2	3.64	2.62
Multi-vegetable juice	100% juice (main constituents: tomato, carrot, beetroot, celery), organic[a]	Naturkind; Vita Verde	2	3.45	0.78	2	8.45	3.92
Vegetable nectars								
Rhubarb nectar *Rheum rhabarbarum*	60% juice	Bauer	1	197.14		1	198.31	
Celeriac nectar *Apium graveolens*	50% juice	Grünfink	1	1.11			–	
Vegetable drinks								
Soybean drink *Glycine max*	62% soymilk	Drinho	1	1.34		1	4.40	
Soybean drink *Glycine max*	6.4% soybeans, organic[a]	Alpro soya	1	0.78		1	1.26	

[a] Organic: plants from organic farming.