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Oxalate content of beverages

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ABSTRACT

A high fluid intake is an integral part of the measures for the recurrence prevention of calcium oxalate stone formation. Since dietary oxalate is a primary risk factor for hyperoxaluria, the oxalate content of a wide variety of alcoholic and non-alcoholic beverages was analyzed using a validated HPLC-enzyme-reactor method. The oxalate concentrations were 3.21–6.34 mg/100 mL in green and black teas, 0.28–1.96 mg/100 mL in iced teas and 0.08–1.82 mg/100 mL in herbal teas. The oxalate levels of soft, wellness, energy and sports drinks were below 0.81 mg/100 mL. The oxalate content varied among beer and wine, ranging from 0.30 mg/100 mL in white wine to 1.78 mg/100 mL in non-alcoholic beer. The oxalate concentration of wines was lower than that of the corresponding fruit juices. Certain beverages may provide considerable amounts of highly bioavailable soluble oxalate. Further studies should examine the effect of fermentation on the oxalate content.

1. Introduction

Calcium oxalate is the major constituent of about 70% of all urinary stones (Lieske et al., 2014). Secondary hyperoxaluria, either based on high dietary intake or increased intestinal absorption of oxalate, is considered a primary risk factor in the pathogenesis of calcium oxalate stone formation (Siener et al., 2003). It has been suggested that dietary oxalate contributes up to 50% of urinary oxalate excretion (Holmes et al., 2001). A high dietary oxalate intake can significantly increase urinary oxalate excretion even in healthy subjects without disturbances in oxalate metabolism (Siener et al., 2013). In calcium oxalate stone patients, intestinal hyperabsorption of oxalate may additionally contribute to urinary oxalate excretion (Voss et al., 2006).

It is well established that copious fluid intake is the most important dietary measure for recurrence prevention of urinary stone formation (Borghi et al., 1996; Fink et al., 2013). Accordingly, dietary recommendations involve increasing fluid intake to obtain a urine volume of at least 2.0–2.5 liters per 24 h (Hesse et al., 2009). A high urine volume decreases the saturation of lithogenous salts, thereby reducing the risk of stone formation (Siener and Hesse, 2003). However, apart from increasing urine volume, beverages may affect urine composition. In particular, care should be exercised to avoid beverages which contain high concentrations of oxalate and which may consequently increase the risk of calcium oxalate stone formation.

Recently, the oxalate content of certain vegetable juices such as rhubarb nectar and beetroot juices has been reported to be considerably high (Siener et al., 2016). While several beverages are known to contain substantial amounts of soluble and therefore highly bioavailable oxalate, e.g., black and green teas (Charrier et al., 2002; Hönow et al., 2010), comprehensive and reliable data on the oxalate content of many other beverages are lacking. As urinary stone formers are encouraged to increase fluid intake, an accurate knowledge of the oxalate content of beverages is highly important. The aim of this study was to determine the oxalate concentration of a wide variety of alcoholic and non-alcoholic beverages, including beer, wine, black, green, herbal and iced teas, soft, energy, sports and wellness drinks.

2. Materials and methods

2.1. Samples and preparation

All beverages were commercially produced and purchased from local establishments in Bonn, Germany. Samples were obtained shortly before analysis. The products are listed in Tables 1–5. The different methods for preparation of tea samples are shown in Tables 2–4. The black and green tea samples were prepared by steeping 1.75 g of leaves in 200 mL 70 °C water for 5 min. For herbal teas, the tea bags were infused in 70 °C water for 5, 10 or 15 min, respectively, according to the manufacturer's instructions. Each tea infusion was cooled to room temperature. The instant iced tea samples were prepared by dissolving 7 g instant powder in 100 mL water. All beverages were shaken prior to analysis.

The measurement of the oxalate content was performed following the method outlined by Hönow and Hesse (2002). For analysis 4 mL of

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Table 1
Oxalate content of beer and wine (mg/100 mL).

	kind of sample	manufacturer		soluble oxalate	
			n	Mean	SD
beer					
beer	Kölsch; 4.8% alc.	Dom; Früh; Gaffel	3	1.50	0.52
beer	Pils; 4.8% alc.	Bitburger; Krombacher	2	1.34	0.81
beer	wheat beer; 5.3% alc.	Erdinger	1	1.30	–
beer	wheat beer with yeast; 5.3% alc./5.5% alc.	Erdinger; Paulaner	2	1.70	0.14
beer	non-alcoholic beer	Bitburger; Löwenbräu	2	1.63	0.78
beer	malt beer	Vitamalz; Feldschlößchen	2	1.78	0.28
wine					
white wine	Pinot gris; 12% alc.	Nagyréde, Hungary	1	0.30	–
white wine	Riesling; 11% alc.	Wine Cooperative Moselland, Germany	1	0.33	–
red wine	Pinot noir; 12.5% alc.	Brogsitter, Germany	1	0.69	–
red wine	60% Mantonegro, 30% Cabernet Sauvignon, 7% Tempranillo, 2% Callet, 1% Syrah; 12% alc.	José L. Ferrer, Spain	1	1.27	–
cider	apples from organic farming; 2.8% alc.	Voelkel	1	0.36	–

alc.: alcohol by volume; SD: standard deviation

Table 2
Oxalate content of black and green tea (mg/100 mL).

	kind of sample	preparation	manufacturer		soluble oxalate	
				n	mean	SD
black tea *Camellia sinensis*						
black tea	Darjeeling	1.75 g/200 mL, 5 min, 70 °C	Lord Nelson	1	6.34	–
black tea	Earl Grey tea from whole leaves of Orange Pekoe	1.75 g/200 mL, 5 min, 70 °C	Meßmer	1	4.62	–
black tea	Earl Grey tea from whole leaves of Orange Pekoe, loose tea	1.75 g/200 mL, 5 min, 70 °C	Meßmer	1	3.94	–
black tea	black tea blend from whole leaves	1.75 g/200 mL, 5 min, 70 °C	Meßmer	1	5.64	–
black tea	black tea blend from Ceylon, India and other provenances	1.75 g/200 mL, 5 min, 70 °C	Teekanne	1	4.92	–
green tea *Camellia sinensis*						
green tea	green tea from China	1.75 g/200 mL, 5 min, 70 °C	Teekanne	1	3.21	–
green tea	green tea, peppermint and lemongrass	1.75 g/200 mL, 5 min, 70 °C	Teekanne	1	3.45	–

SD: standard deviation

samples were filtered (folder filter, 80 mm in diameter; Schleicher & Schuell GmbH, Erdmannhausen, Germany) and directly acidified with 50 µL 2 N hydrochloric acid (p.a.; Merck, Darmstadt, Germany) to stabilize ascorbic acid potentially present. Oxalate generation due to oxidation of ascorbic acid occurs at pH values above 5.0 (Chalmers et al., 1985). The acidification of the filtrate with 50 µL 2 N hydrochloric acid to a pH below 5.0 can prevent oxalate generation during sample preparation (Hönow and Hesse, 2002). Since no residues were left after filtration, the determination of the insoluble oxalate content of beverages was not required (Hönow and Hesse, 2002; Siener et al., 2016). The samples were immediately analyzed by HPLC-enzyme-reactor method after dilution. All samples were analyzed in duplicate. If one sample was analyzed in duplicate, the mean value was indicated. Mean and standard deviations were reported, if the number of samples of different origin was two or more. The detection limit was 0.68 µM/L (0.06 mg/L) (Hönow and Hesse, 2002). 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.

Table 3
Oxalate content of iced tea (mg/100 mL).

	kind of sample	manufacturer		soluble oxalate	
			n	mean	SD
iced tea					
black tea, apple	water, black tea extract, apple juice, ready-to-drink	Lipton	1	1.58	–
black tea, lemon	water, black tea extract, flavour, ready-to-drink	Flight; Hardthof; Euroshopper	3	0.65	0.21
black tea, lemon	water, black tea extract, lemon juice, ready-to-drink	Comet; Natreen; Lipton	3	1.38	0.41
black tea, lemon-lime	black tea, lemon and lime juice, ready-to-drink	Pfanner	1	0.92	–
black tea, peach	water, black tea extract, flavour, ready-to-drink	A & P; Flight	2	0.83	0.29
black tea, peach	water, black tea extract, lemon and peach juice, ready-to-drink	Comet	1	1.15	–
black tea, lemon, instant	black tea extract, lemon fruit powder; 7 g instant powder/100 mL	Krüger	1	0.53	–
black tea, peach, instant	black tea extract, flavour; 7 g instant powder/100 mL	Krüger	1	0.73	–
green tea, grapefruit	water, green tea extract, flavour, ready-to-drink	Lipton	1	1.96	–
green tea, lemon-prickly pear	green tea, apple and lemon juice, ready-to-drink	Pfanner	1	1.06	–
red tea blend, lemon-lotus blossom	hibiscus, rooibos and pu-erh tea, apple and lemon juice, ready-to-drink	Pfanner	1	0.28	–

SD: standard deviation.

Table 4
Oxalate content of herbal tea (mg/100 mL).

	kind of sample	preparation	manufacturer	*n*	soluble oxalate	
					mean	SD
herbal tea						
honey bush tea *Cyclopia intermedia*	honey bush leaves	1.8 g/200 mL, 5 min, 70 °C	Bad Heilbrunner	1	0.08	–
peppermint tea *Mentha piperita*	peppermint leaves	1.8 g/200 mL, 5 min, 70 °C	Westcliff; kd	2	0.74	0.15
rooibos tea *Aspalathus linearis*	rooibos, flavour	1.8 g/200 mL, 5 min, 70 °C	Teekanne; Westcliff	2	0.68	0.14
barley malt tea	barley malt (45%), roasted carob, chicory root, cardamom, cinnamon (9%), licorice root, black pepper	2.0 g/200 mL, 5 min, 70 °C	Meßmer	1	1.82	–
fruit tea blend, apricot	rose hip, hibiscus, apples, flavour, orange peel, citric acid, ascorbic acid, elderberries, apricot fruit granules	3.0 g/200 mL, 5 min, 70 °C	Westcliff	1	0.68	–
fruit tea blend, multi-vitamin	hibiscus, rose hip, apples, calcium sulfate, orange peel, berry flavour, blue berry, black currant, elderberry, vitamins	3.0 g/200 mL, 5 min, 70 °C	Teekanne	1	0.41	–
herbal tea (kidney and bladder tea)	*Orthosiphon* leaves (37.5%), restharrow root (37.5%), birch leaves, bean-pods, licorice root, rose hip peel, fennel fruits	1.8 g/150 mL, 15 min, 70 °C	Bad Heilbrunner	1	0.83	–
herbal tea (stomach and intestine tea)	peppermint leaves (25%), anise (15%), bitter fennel (15%), chamomile blossoms (15%), caraway (15%), valerian root, melissa leaves, cinnamon bark	1.75 g/200 mL,10 min, 70 °C	St. Benedikt	1	0.52	–
herbal tea blend	rooibos, blackberry leaves, orange and vanilla flavour, verbena, peppermint, chamomile, fennel, licorice root, cinnamon	2.0 g/200 mL, 5 min, 70 °C	Teekanne	1	0.87	–
lapacho tea	lapacho bark, pimento, fennel, cardamom, cinnamon, coriander, flavour, cloves	2.0 g/200 mL, 5 min, 70 °C	Teekanne	1	0.43	–
mate and guarana	lemon grass, roasted mate (31%), cinnamon, flavour, guarana (5%), black tea extract (5%), kola nuts (caffeine content: 2 g/100 g)	2.0 g/200 mL, 5 min, 70 °C	Milford	1	1.21	–
rose hip tea with hibiscus	rose hip, hibiscus	2.0 g/200 mL, 5 min, 70 °C	Marco Polo	1	0.35	–
six-herbs tea blend	hibiscus, lemon grass, blackberry leaves, rose hip, peppermint, lemon verbena	2.0 g/200 mL, 5 min, 70° C	Meßmer	1	0.81	–

SD: standard deviation.

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 Model 300 with Gina 50 autosampler, Gynkotek, Germering, Germany) consisted of an anion exchange column (AS4A-DIONEX; ThermoFisher Scientific, Waltham, MA), a mobile phase of aqueous EDTA solution (2.0 g/L, adjusted to pH 5.0 with 0.3 mol/L NaOH; flow rate: 0.6 mL/min; 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, MO; 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).

3. Results

The oxalate contents of various types of alcoholic and non-alcoholic beverages are listed in Tables 1–5. The highest oxalate concentrations, ranging from 3.21 to 6.34 mg/100 mL, were found in black and green teas. The oxalate values of iced teas containing extracts from black or green tea were between 0.53 and 1.96 mg/100 mL. Low levels of oxalate were found in herbal teas (0.08 to 0.87 mg/100 mL), except for barley malt (1.82 mg/100 mL) and mate-guarana tea (1.21 mg/100 mL). The oxalate concentration of soft, wellness, energy and sports drinks were below 0.81 mg/100 mL. Among wine, the oxalate levels were highest in red wine (0.69 to 1.27 mg/100 mL) and lowest in white wine and cider (0.30 to 0.36 mg/100 mL). The oxalate content of alcoholic and non-alcoholic beer was similar, ranging from 1.30 to 1.78 mg/100 mL, but higher than that of wine.

4. Discussion

The most important measure for the prevention of urinary stone recurrence is a high urine dilution (Borghi et al., 1996; Fink et al., 2013). To ensure an adequate urine volume, a daily fluid intake of at least 2.5 to 3.0 liters is recommended (Hesse et al., 2009). Because a high dietary oxalate intake can markedly contribute to urinary oxalate excretion, a primary risk factor for calcium oxalate stone formation, the oxalate content of beverages should be considered.

The highest oxalate concentrations were found in black and green teas, ranging from 3.21 to 6.34 mg/100 mL. Among black teas, the highest oxalate content was present in Darjeeling tea, which is known as a high quality tea, whereas Earl Grey tea revealed the lowest oxalate levels. In many countries tea is the most commonly consumed beverage, secondly to water. The consumption of 1 liter of black or green tea would result in an intake of between 32 and 63 mg soluble and therefore highly bioavailable oxalate per day. These values are within the range of those previously reported for black and green teas (Charrier et al., 2002; Hönow and Hesse, 2002; Hönow et al., 2010; McKay et al., 1995). The present results confirm previous findings that tea is a considerable source of oxalate intake (Hönow et al., 2010). For calcium oxalate stone formers, the intake of black teas with milk could reduce intestinal oxalate absorption by binding oxalate to calcium (Charrier et al., 2002; Savage et al., 2003).

Data on the oxalate content of iced teas have been lacking so far. In the present study, the oxalate content of iced teas containing extracts from black or green tea was between 0.53 and 1.96 mg/100 mL and therefore lower than that of black and green teas. However, the intake of 2 liters of iced tea per day would provide up to approximately 40 mg highly bioavailable soluble oxalate. Calcium oxalate stone formers

Table 5
Oxalate content of soft, energy, wellness and sport drinks (mg/100 mL).

	kind of sample	manufacturer		soluble oxalate	
			n	mean	SD
wellness drinks					
aloe vera drink	beverage with 50% multi-fruit juice (apple, orange, pineapple, passion fruit, mango, lemon), 20% aloe vera juice and vitamins	Pro Health	1	0.28	–
apple-sea buckthorn drink	beverage with multi-fruit juice (2.5% grape, 2.0% apple, 0.5% sea buckthorn juice from concentrates) and vitamins	Kneipp	1	0.06	–
bread drink	beverage from fermented whole grain bread (wheat, rye, oats)	Kanne	1	0.72	–
grape-St. John's wort drink	beverage with 5% grape juice (from concentrate), extracts of St. John's wort and lemon balm and vitamins	Kneipp	1	0.04	–
kombucha drink	low-calorie beverage with 29% fermented herbal tea (water, multi-fruit juice concentrate, herbal extract, kombucha cultures) and 28.5% fruit tea	Pro Health	1	0.30	–
kombucha herbal tea drink	herbal tea infusion (herbal tea blend) with kombucha cultures and lactobacillus	Stock Vital	1	0.44	–
vital drink	beverage based on fermented cereals and 20% multi-fruit juice (orange, apple, passion fruit juice from concentrates, mango pulp) and vitamins	Pro Health	1	0.31	–
vital apple-mint drink	beverage with multi-fruit juice (45% apple, 4% quince, lemon) and extracts of green tea and peppermint	Dr. Koch	1	0.81	–
vital drink apple, peach, passion fruit	beverage with 70% multi-fruit juice (apple, peach, grape, passion fruit, acerola and lemon juice from concentrates) and extracts of red malva, artichoke and melissa	Hohes C	1	0.35	–
soft drinks					
cola, regular	caffeinated soft drink	Afri Cola; Coca-Cola; Pepsi; Sinalco	4	0.10	0.05
cola, diet	caffeinated low-calorie soft drink	Afri Cola; Coca-Cola; Pepsi	3	0.10	0.00
lemon soda	soft drink with lemon flavor	Pepsi; Sinalco	2	0.06	0.01
orange soda	soft drink with orange flavor	Coca-Cola	1	0.18	
ginger ale	soft drink with ginger extract	Schweppes	1	0.04	
tonic water	soft drink with quinine	Schweppes	1	0.05	
bitter lemon	soft drink with 3% lime juice and quinine	Schweppes	1	0.10	
energy drinks					
Caps Energy apple, grape, blackcurrant	with fruit juice (10%), guarana, taurine, caffeine (25 mg/100 mL)	Capri-Sonne, Deutsche SiSi Werke, Germany	1	0.21	
Red Bull	Red Bull	Red Bull	1	0.09	
sports drinks					
Powerade	isotonic drink	Coca-Cola	1	LOD	
Trendy Isorade lemon	low-calorie isotonic drink	Plus	1	0.24	

LOD: Limit of detection (0.006 mg/100 mL); SD: standard deviation

should refrain from the consumption of iced teas.

Except for barley malt (1.82 mg/100 mL) and mate-guarana tea (1.21 mg/100 mL), low oxalate concentrations were found in herbal teas, ranging from 0.08 to 0.87 mg/100 mL. The low oxalate levels were close to those reported previously (Charrier et al., 2002; McKay et al., 1995). The herbal teas measured by McKay and co-workers (1995) using an enzymatic method contained 0.25 to 0.69 mg/100 mL oxalate. Due to their low oxalate contents, the majority of herbal teas is suitable for increasing urine volume and, therefore, can be recommended for the recurrence prevention of urinary stones as an alternative to black and green teas. The unexpectedly higher oxalate concentration of barley malt (1.82 mg/100 mL) and mate-guarana tea (1.21 mg/100 mL) can be explained by the content of ingredients, e.g. black tea, mate and black pepper that are known to contain oxalate (Hönow and Hesse, 2002).

Comprehensive and reliable data on the oxalate content of soft, wellness, energy and sports drinks are not available. The analyzed drinks contained low levels of oxalate, ranging from not detected to 0.81 mg/100 mL. The highest oxalate concentrations were found in vital apple-mint drink and bread drink, probably due to their content of oxalate-containing green tea extracts and fermented whole grain bread, respectively (Hönow et al., 2010; Siener et al., 2006). Although these drinks are low in oxalate, the intake of sugar-sweetened beverages contributes to energy surplus. In addition, the phosphoric acid content of cola beverages increases dietary phosphate intake. Previous studies found that consumption of soft drinks acidified by phosphoric acid causes unfavourable changes in urine composition and is associated with an increased risk of urinary stone recurrence (Rodgers, 1999; Shuster et al., 1992).

The oxalate content of various types of alcoholic and non-alcoholic beer was similar, ranging from 1.30 to 1.78 mg/100 mL, but higher than that of wine. It is suggested that the oxalate content in beer is primarily derived from malted barley and/or wheat, cereals that are known to contain oxalate (Siener et al., 2006).

Comprehensive and reliable data on the oxalate content of different types of wines are still lacking. Among the analyzed wines, red wines contained higher levels of oxalate (0.69–1.27 mg/100 mL) than white wines (0.30–0.33 mg/100 mL) and cider (0.36 mg/100 mL). Corresponding to the oxalate content of wines, juices from red grapes were found to contain higher oxalate concentrations than those from white grapes (3.93 mg/100 mL and 1.50 mg/100 mL, respectively) and apple juice (0.87 mg/100 mL) (Siener et al., 2016). Overall, the oxalate content of these wines was approximately 2.5 to 5 times lower than that of the corresponding fruit juices, which have been analyzed using the same HPLC-enzyme-reactor method. Interestingly, *Saccharomyces cerevisiae*, a species of yeast generally used in the wine making process, demonstrated potential for oxalate-degrading activity during fermentation of *Icacina mannii* (a starchy tuber) (Antai and Obong, 1992). Fermentation of *Icacina mannii* paste with *Saccharomyces cerevisiae* resulted in a decrease in the oxalate content from 638 mg/kg to 463 mg/kg (Antai and Nkwelang, 1998). The lower oxalate content found in the analyzed wines compared to the corresponding fruit juices could be associated with the oxalate-degrading potential of *Saccharomyces cerevisiae* during fermentation. Further studies are necessary to examine the effect of fermentation with *Saccharomyces cerevisiae* on the oxalate concentration of wines.

5. Conclusions

The determination of the oxalate content of various types of alcoholic and non-alcoholic beverages is required as an important precondition for the accurate assessment of dietary oxalate intake and the recommendation of suitable beverages in calcium oxalate stone disease. The highest oxalate concentrations were found in black, green and iced teas containing extracts from black or green tea. Low levels of oxalate were found in herbal teas, except for barley malt and mate-guarana tea, soft, wellness, energy and sports drinks. The oxalate content of cider, red and white wines was 2.5 to 5 times lower than that of the corresponding fruit juices, which could be associated with the oxalate-degrading potential of *Saccharomyces cerevisiae* during fermentation. Certain types of tea and non-alcoholic beer may provide considerable amounts of highly bioavailable soluble oxalate.

Conflict of Interest

None.

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References

Antai, S.P., Nkwelang, G., 1998. Reduction of some toxicants in *Icacina mannii* by fermentation with *Saccharomyces cerevisiae*. Plant Foods Hum. Nutr. 53, 103–111.
Antai, S.P., Obong, U.S., 1992. The effect of fermentation on the nutrient status and on some toxic components of *Icacinia manni*. Plant Foods Hum. Nutr. 42, 219–224.
Borghi, L., Meschi, T., Amato, F., Briganti, A., Novarini, A., Giannini, A., 1996. Urinary volume, water and recurrences in idiopathic calcium nephrolithiasis: a 5-year randomized prospective study. J. Urol. 155, 839–843.
Chalmers, A.H., Cowley, D.M., McWhinney, B.C., 1985. Stability of ascorbate in urine: relevance to analyses for ascorbate and oxalate. Clin. Chem. 31, 1703–1705.
Charrier, M.J.S., Savage, G.P., Vanhanen, L., 2002. Oxalate content and calcium binding capacity of tea and herbal teas. Asia Pac. J. Clin. Nutr. 11, 298–301.
Fink, H.A., Wilt, T.J., Eidman, K.E., Garimella, P.S., MacDonald, R., Rutks, I.R., Brasure, M., Kane, R.L., Ouellette, J., Monga, M., 2013. Medical management to prevent recurrent nephrolithiasis in adults: a systematic review for an American College of Physicians clinical guideline. Ann. Intern. Med. 158, 535–543.
Hönow, R., Hesse, A., 2002. Comparison of extraction methods for the determination of soluble and total oxalate in foods by HPLC-enzyme-reactor. Food Chem. 78, 511–521.
Hönow, R., Bongartz, D., Hesse, A., 1997. An improved HPLC-enzyme-reactor method for the determination of oxalic acid in complex matrices. Clin. Chim. Acta 261, 131–139.
Hönow, R., Gu, K.L.R., Hesse, A., Siener, R., 2010. Oxalate content of green tea of different origin, quality, preparation and time of harvest. Urol. Res. 38, 377–381.
Hesse, A., Tiselius, H.G., Siener, R., Hoppe, B., 2009. Urinary Stones: Diagnosis, Treatment, and Prevention of Recurrence, 3rd ed. Karger, Basel.
Holmes, R.P., Goodman, H.O., Assimos, D.G., 2001. Contribution of dietary oxalate to urinary oxalate excretion. Kidney Int. 59, 270–276.
Lieske, J.C., Rule, A.D., Krambeck, A.E., Williams, J.C., Bergstralh, E.J., Mehta, R.A., Moyer, T.P., 2014. Stone composition as a function of age and sex. Clin. J. Am. Soc. Nephrol. 9, 2141–2146.
McKay, D.W., Seviour, J.P., Comerford, A., Vasdev, S., Massey, L.K., 1995. Herbal tea: an alternative to regular tea for those who form calcium oxalate stones. J. Am. Diet. Assoc. 95, 360–361.
Rodgers, A., 1999. Effect of cola consumption on urinary biochemical and physicochemical risk factors associated with calcium oxalate urolithiasis. Urol. Res. 27, 77–81.
Savage, G.P., Charrier, M.J.S., Vanhanen, L., 2003. Bioavailability of soluble oxalate from tea and the effect of consuming milk with the tea. Eur. J. Clin. Nutr. 57, 415–419.
Shuster, J., Jenkins, A., Logan, C., Barnett, T., Riehle, R., Zackson, D., Wolfe, H., Dale, R., Daley, M., Malik, I., Schnarch, S., 1992. Soft drink consumption and urinary stone recurrence: a randomized prevention trial. J. Clin. Epidemiol. 45, 911–916.
Siener, R., Hesse, A., 2003. Fluid intake and epidemiology of urolithiasis. Eur. J. Clin. Nutr. 57 (Suppl. 2), S47–S51.
Siener, R., Ebert, D., Nicolay, C., Hesse, A., 2003. Dietary risk factors for hyperoxaluria in calcium oxalate stone formers. Kidney Int. 63, 1037–1043.
Siener, R., Hönow, R., Voss, S., Seidler, A., Hesse, A., 2006. Oxalate content of cereals and cereal products. J. Agric. Food Chem. 54, 3008–3011.
Siener, R., Bade, D.J., Hesse, A., Hoppe, B., 2013. Dietary hyperoxaluria is not reduced by treatment with lactic acid bacteria. J. Transl. Med. 11, 306.
Siener, R., Seidler, A., Voss, S., Hesse, A., 2016. The oxalate content of fruit and vegetable juices, nectars and drinks. J. Food Compos. Anal. 45, 108–112.
Voss, S., Hesse, A., Zimmermann, D.J., Sauerbruch, T., von Unruh, G.E., 2006. Intestinal oxalate absorption is higher in idiopathic calcium oxalate stone formers than in healthy controls: measurements with the [$^{13}C_2$] oxalate absorption test. J. Urol. 175, 1711–1715.