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UROLITHIASIS

Variations in the mineral content of bottled 'carbonated or sparkling' water across Europe: a comparison of 126 brands across 10 countries

Simone J.M. Stoots[1], Rob Geraghty[2], Guido M. Kamphuis[1], Enakshee Jamnadass[3], Michaël M.E.L. Henderickx[1], Eugenio Ventimiglia[4], Olivier Traxer[5], Etienne X. Keller[6], Vincent De Coninck[7], Michele Talso[8], Panagiotis Kallidonis[9], Esteban Emiliani[10], Ewa Bres-Niewada[11], Sadaf S. Karim[3], Angela Piccirilli[10], Athanasios Vagionis[9], Bhaskar K. Somani[3]

[1]*University of Amsterdam, Amsterdam UMC, Department of Urology, Amsterdam, The Netherlands*
[2]*Freeman Hospital, Department of Urology, Newcastle, United Kingdom*
[3]*University Hospital Southampton NHS Trust, Department of Urology, Southampton, United Kingdom*
[4]*IRCCS Ospedale, Urological Research Institute, Division of Experimental Oncology/Unit of Urology, San Raffaele, Milan, Italy*
[5]*Sorbonne University, GRC#20 Urolithiasis, Paris, France*
[6]*University of Zurich, University Hospital Zurich, Department of Urology, Zurich, Switzerland*
[7]*AZ Klina, Department of Urology, Brasschaat, Belgium*
[8]*ASST Fatebenefratelli-Sacco – Luigi Sacco University Hospital, Department of Urology, Milan, Italy*
[9]*University of Patras, Department of Urology, Patras, Greece*
[10]*Fundació Puigvert, Autonomous University of Barcelona, Department of Urology, Barcelona, Spain*
[11]*Roefler Memorial Hospital, Department of Urology, Pruszków, Poland*

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Corresponding author
Simone J.M. Stoots
University of Amsterdam
Amsterdam UMC
Department of Urology
9 Meibergdreef
1105 AZ Amsterdam,
The Netherlands
phone: +31 647 944 916
simone.stoots@gmail.com

Introduction Kidney stone disease is a common disease with high recurrence rates. Sufficient intake of water is the cornerstone in primary prevention of stone disease. However, the mineral composition of water can affect urinary minerals and influence stone formation. The aim of this study is to assess the variation in the mineral composition of bottled sparkling or carbonated drinking water across Europe.

Material and methods The two largest supermarket chains in each participating country were visited to obtain data on mineral composition regarding bicarbonate, calcium, magnesium, potassium, sodium and sulphates of sparkling or carbonated waters by reading the ingredient labels on the bottles supplied by the manufacturers. Alternatively, the web-shops of these supermarkets were consulted.

Results In total, 126 sparkling water brands across ten European countries were analysed regarding mineral composition. The median concentrations per mineral varied greatly. The greatest variation in median mineral content was found for sodium and sulphates with levels ranging from 3.1 mg/l to 63.0 mg/l and 6.0 mg/l to 263.0 mg/l respectively. A wide distribution of calcium content was found in Switzerland, with calcium levels reaching up to 581.6 mg/l.

Conclusions This study confirms that the mineral composition of sparkling or carbonated water varies greatly across Europe. Patients with kidney stone disease should be aware that the mineral content of water may influence stone formation and be mindful of the great variation that exists between different water brands. Mineral water can be a source of potential promotors or inhibitors of stone formation and patients and urologists need to be mindful of this.

Key Words: urolithiasis ‹› kidney stone disease ‹› mineral content ‹› mineral composition ‹› sparkling water

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INTRODUCTION

Kidney stone disease (KSD) has a life time prevalence rate of up to 14% in Europe with a recurrence rate of 50% in 5–10 years [1, 2]. It is characterised by stone formation in the urinary tract and while there has been a lot of research in stone treatment with several treatment options available, comparatively little research has been done for primary stone prevention. The incidence of kidney stone disease has been rising due to multiple factors including more imaging, warm weather, a rise in obesity and metabolic syndrome [3, 4, 5]. Apart from the morbidity and health impact, it also affects patients' quality of life and is a costly disease comparable to the combined cost of prostate and bladder cancer [6, 7].

It is generally accepted that sufficient fluid intake has a role in the primary prevention of stone disease, with the aim of achieving a urine output of two litres or more per day [8]. This leads to an increase in urine output and resultant dilution of lithogenic factors such as oxalate, calcium and uric acid, consequently reducing crystallization of calcium salts. With increased diuresis, there is less stagnation of urine which can serve as a mechanical factor in stone formation [9, 10].

A high water intake and hydration seems to be the cornerstone in the prevention of kidney stone disease. The mineral composition of water from different sources can also affect urinary minerals and influence stone formation. Enormous variation has been shown in tap water and different brands of mineral water [11, 12, 13]. While 'still' water is commonly consumed, 'sparkling' water infused with carbon dioxide gas under pressure is also preferred by some as drinking water or as a mixer with other drinks. The aim of this study was to analyse 'sparkling or carbonated' water to assess variation in mineral compositions across different manufacturers and countries within Europe.

MATERIAL AND METHODS

This study aims to provide a complete overview of the mineral composition of sparkling or carbonated bottled drinking water across Europe. It is a multinational study that was conducted in ten European countries including Belgium, France, Germany, Greece, Italy, the Netherlands, Poland, Spain, Switzerland and the United Kingdom. In each country, the two largest supermarket chains were visited to obtain raw data on the mineral composition of sparkling or carbonated waters by reading the ingredient labels on the bottles supplied by the manufactures. Alternatively, the web-shops of these supermarkets were consulted. The minerals studied were bicarbonate, calcium, magnesium, potassium, sodium and sulphates. Data collection was performed from October 2019 – December 2019 by an individual from every country included in the study.

Statistical analysis

The software Statistical Package for Social Sciences (SPSS), version 26 (IBM CORP., Armonk, New York, USA) was used to analyse the data. First, the data were checked for normality. All data were treated as non-parametric data as they were not normally distributed.

For optimal graphic representation of the data, simple box plots were used. Furthermore, by using box plots the distributional features of the data could be examined. Outliers and extremes values are displayed as circles and asterisks respectively.

Table 1. *Mineral composition (mg/l) of bottled sparkling or carbonated water by country (median [IQR])*

Country	Mineral composition (mg/l)					
	Bicarbonate	Calcium	Magnesium	Potassium	Sodium	Sulphates
Belgium	220.0 [180.0–317.0]	56.0 [13.5–151.5]	7.0 [2.0–18.0]	2.0 [1.0–5.0]	10.6 [9.0–33.3]	19.0 [8.0–33.0]
France	1175.0 [710.0–1837.0]	51.5 [90.0–185.0]	15.0 [8.0–49.0]	3.0 [11.0–52.0]	10.0 [7.5–381.0]	30.0 [20.0–59.0]
Germany	253.0 [189.0–349.0]	67.5 [47.0–142.0]	23.0 [5.0–42.0]	2.0 [1.0–4.0]	15.8 [13.3–29.9]	36.0 [9.0–162.0]
Greece	344.2 [274.0–781.0]	87.2 [59.3–188.0]	24.0 [3.0–53.0]	0.0 [0.0–0.0]	6.0 [4.4–20.0]	11.0 [5.0–12.0]
Italy	212.6 [57.4–930.0]	43.5 [9.1–164.0]	13.0 [2.0–25.0]	1.0 [1.0–2.0]	3.1 [1.5–6.0]	6.0 [4.0–18.0]
Netherlands	190.0 [170.0–360.0]	68.5 [40.9–101.5]	7.0 [3.0–18.0]	2.0 [1.0–3.0]	10.3 [6.0–30.6]	29.0 [9.0–37.0]
Poland	1260.0 [335.6–1550.0]	80.9 [97.8–301.0]	52.0 [13.0–153.0]	7.0 [2.0–49.0]	63.0 [4.6–118.0]	29.0 [27.0–32.0]
Spain	287.0 [215.5–1935.5]	55.0 [32.0–86.8]	8.0 [4.0–31.0]	9.0 [3.0–49.0]	38.8 [7.6–835.5]	11.0 [7.0–48.0]
Switzerland	273.5 [243.5–360.5]	91.0 [97.7–330.0]	36.0 [22.0–52.0]	2.0 [1.0–3.0]	5.2 [4.0–7.0]	263.0 [55.0–85.0]
United Kingdom	240.0 [215.0–245.0]	56.0 [55.0–104.0]	18.0 [10.0–19.0]	2.0 [1.0–2.0]	11.5 [7.5–24.0]	13.0 [9.0–28.0]

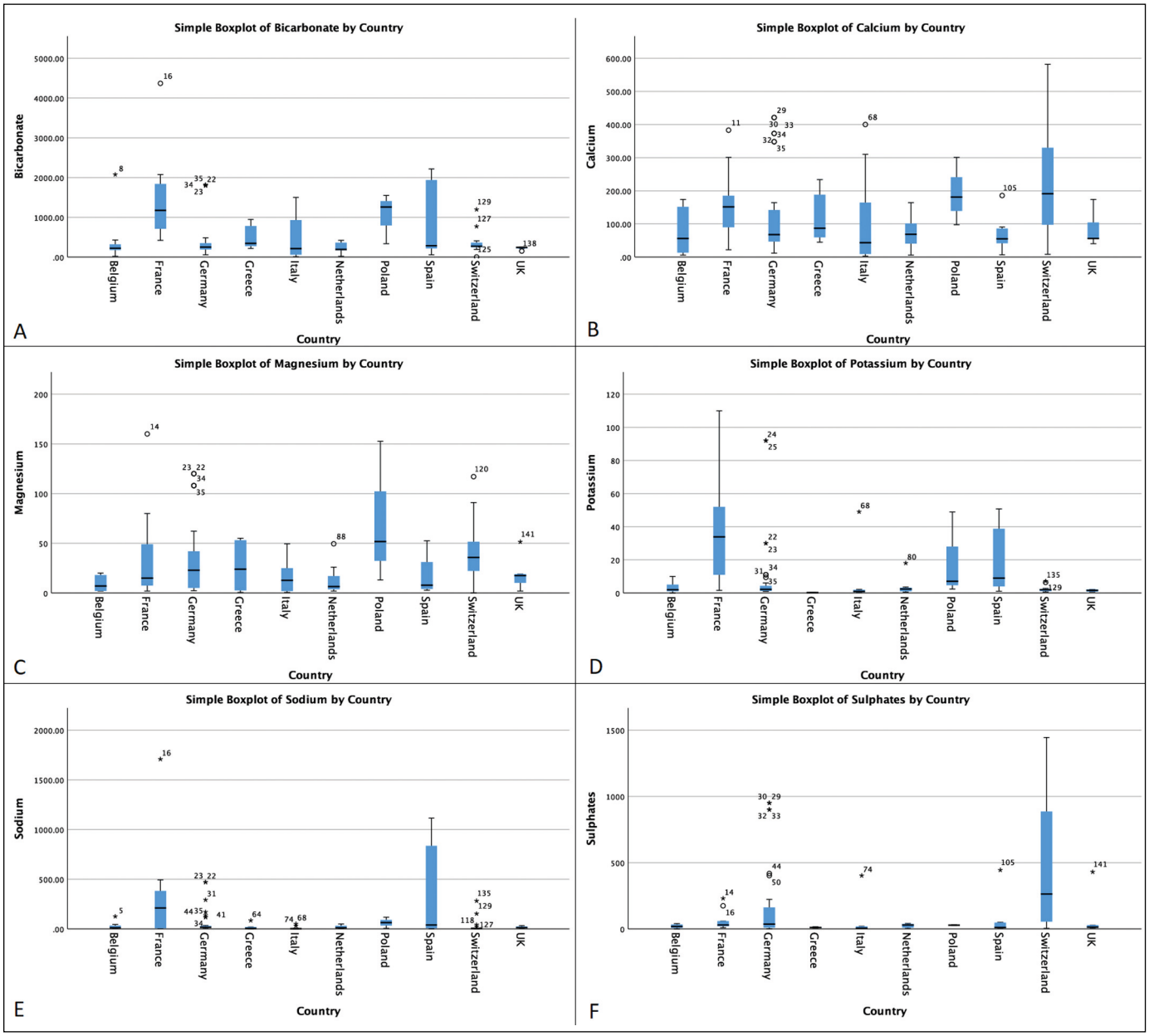

Figure 1. *Simple boxplots of the mineral composition (mg/l) of bottled sparkling or carbonated water per mineral by country.*

RESULTS

In total, 126 different commercial water brands for sparkling or carbonated bottled drinking water across ten European countries were analysed regarding the mineral composition. The following commercial water brands for sparkling or carbonated water were sold in up to eight different countries: Bar le Duc, Chaudfontaine, Gerolsteiner Medium, Perrier, San Benedetto, San Pellegrino, Sourcy and Spa Intense.

Table 1 shows the mineral composition of sparkling or carbonated bottled drinking water across Europe expressed as median [IQR]. The median concentrations per mineral varied greatly within Europe. Bicarbonate concentration ranged from 212.6 mg/l in Italy to 1260.0 mg/l in Poland. Calcium concentration ranged from 43.5 mg/l to 91.0 mg/l. Magnesium concentration ranged from 7.0 mg/l in Belgium and the Netherlands to 52.0 mg/l in Poland. The median mineral concentration across Europe shows the greatest variation for sodium and sulphates with levels ranging from 3.1 mg/l to 63.0 mg/l and 6.0 mg/l to 263.0 mg/l respectively.

The lowest median concentration per mineral were found in Italy, except for magnesium and potassium.

Sparkling or carbonated waters available in Poland showed the highest median concentrations regarding bicarbonate, magnesium and sodium.
The distributional features of the mineral composition of sparkling or carbonated bottled waters across Europe per mineral are shown in Figure 1. The boxplots visualize a great variability in mineral composition per mineral. Calcium and sulphates content of sparkling or carbonated waters sold in Switzerland show a wide distribution compared to the other participating countries. The range for calcium content in Switzerland reaches 573.2. For sulphates, with a minimum of 3.8 and a maximum of 1445.0, the range was 1441.2. Potassium levels varied greatly in France, from 0 mg/l to 110 mg/l.

DISCUSSION

This multi-national study, conducted in ten European countries including Belgium, France, Germany, Greece, Italy, the Netherlands, Poland, Spain, Switzerland and the United Kingdom, demonstrates the wide variation in the mineral content of bottled sparkling or carbonated water from 126 brands which are commercially available across Europe. The average bicarbonate content across Europe varies with a factor of 5.9. What is more, the average sulphate concentration varies with a factor of 43.8.
It is noteworthy that the calcium content of sparkling or carbonated waters sold in Switzerland, varied enormously. Here, the calcium content varied from 8.4 mg/l (San Clemente Frizzante) to 581.6 mg/l (Meltinger). Of all water brands included in our study, sparkling water from Meltinger contained the highest calcium content. In fact, 75% of the water with a calcium content exceeding 400 mg/l originated from Switzerland. These included Adelbodner Mineral (579.0 mg/l), Farmer Mineral Rot (564.0 mg/l), Adello Mineral (530.0 mg/l), Eptinger Pricklnd (510.0 mg/l) and Valser (435.0 mg/l). Carolinen Classic and Carolinen Medium, which are sold in Germany contained 421.0 mg/l of calcium. The lowest calcium concentration of all the waters included in our study was 2.9 mg/l from Sant' Anna, Italy. This means that the overall calcium content across Europe could be 200 times as high in one country compared to another.
Several studies, which are recently evaluated in a systematic review by Sulaiman et al., show that drinking 2 L of water with high calcium content, that is more than 232 mg/l, results in hypercalciuria, a risk factor for calcium stone formation [11]. Therefore, for patients with KSD, it is important to realize the extent to which calcium levels of drinking water vary as high calcium intake may influence stone formation. Nowadays, patients are advised a normal-calcium diet, which is 1000–1200 mg of calcium daily [14, 15]. By drinking 2.5 L of Meltinger sparkling water, with a calcium content of 581.6 mg/l, the daily intake of calcium is already exceeded. In other words, although water helps to prevent kidney stone disease, kidney stone patients must be aware of this level of calcium in the water and balance calcium rich foods like cheese, milk or yoghurt, which can also be a high source of calcium intake.
However, calcium is not the only mineral affecting stone formation. Excessive intake of sodium also promotes kidney stone disease as it increases urinary calcium excretion in patients suffering from idiopathic calcium stone disease and hypercalciuria [16]. For these patients, a low-sodium diet is suggested. However, some of the water included in our study had high sodium levels. Water with a sodium content exceeding 1000 mg/l were San Narciso (1080.0 mg/l), Vichy Catalan (1097.0 mg/l) and Malavella (1115.0 mg/l) all available in Spain, and Saint-Yorre (1708.0 mg/l) which is sold in France.
Although excessive amounts of calcium and sodium might negatively influence stone formation, other minerals might prevent stone recurrence in kidney stone disease. Water with high bicarbonate content, for example, might be beneficial regarding kidney stone formation. A study performed by Siener et al., which evaluated the effect of mineral water rich in calcium, magnesium and bicarbonate, suggested that hypercalciuria as an effect of high calcium content of mineral water is counterbalanced by its high levels of bicarbonate and magnesium which results in an increase in citrate excretion [17]. Furthermore, bicarbonate intake creates alkalinity resulting in a higher urinary pH. If 1.5 L of water is drunk with a bicarbonate content of 2673 mg/l, it leads to metaphylactic levels of it as shown by a clinical study by Karagülle et al., decreasing the risk of uric acid precipitation. In addition, mineral water with high bicarbonate content promotes excretion of inhibitory elements like magnesium and citrate and might therefore decrease calcium oxalate stone formation [18]. Our study includes one water with such high bicarbonate levels: Saint Yorre (4368.0 mg/l) sold in France. However, this type of sparkling water also had the highest sodium content of all included water brands across Europe, suggesting that sparkling waters with solely a high bicarbonate content are not commercially available.
A previous study has assessed the variation in mineral content of bottled 'still' water, however this is the first study that assessed the variation in the mineral content of bottled sparkling or carbonated water across Europe [12]. Our study does however have

some limitations. In Europe, tap water is mostly of adequate quality, so it would be interesting to analyse its mineral composition as some people might not be able to afford bottled water, being relatively expensive compared to tap water. On the contrary, the consumption of bottled water is increasing in the European Union [19]. We also did not look at 'mineral water' composition which is also consumed by some patients.

In addition to this, our study only included bottled waters that are sold in the two largest supermarkets chain per country. Further research must be done to provide a complete overview of the mineral content of sparkling or carbonated waters that are available all over Europe. A worldwide study evaluating the mineral content of bottled drinking water is also suggested to properly advise kidney stone patients regarding water intake.

Over time, several studies have been conducted to evaluate the effect of mineral water on the development of kidney stones. However, due to the complex and multifactorial aetiology of stone formation, it remains difficult to determine to what extend the mineral content of water affects stone formation.

CONCLUSIONS

This study confirms that the mineral composition of sparkling or carbonated water varies greatly across Europe. Patients with kidney stone disease should be aware that the mineral content of water may influence stone formation and be mindful of the great variation that exists between different water brands. Mineral water can be a source of potential promotor or inhibitor of stone formation and patients and urologists need to be mindful of this.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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