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Original Article

Survey of the chemical composition of 571 European bottled mineral waters

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ABSTRACT

As part of the European TRACE project (Tracing Food commodities in Europe, VI FP, Contract N. 006942), this paper provides a wide-ranging survey of the chemical composition of 571 mineral waters bottled and marketed in 23 European countries, and discusses 39 compositional parameters (specific electric conductivity, pH, hardness, total alkalinity, ammonia, chloride, fluoride, nitrate, nitrite, sulphate, Ca, K, Mg, Na, Al, B, Ba, Cd, Ce, Co, Cs, Cu, La, Li, Lu, Mn, Mo, Nd, Ni, Pb, Rb, Se, Sm, Sr, Tl, U, V, Yb, Zn) mainly referring to legal limits and nutritional implications. According to European legislation 58.1% of samples could be defined as 'suitable for a low-sodium diet' while 8.1% could be defined as 'containing sodium', 13.7% could be labelled as 'containing magnesium', 10.2% as 'containing fluoride', 4.9% as 'containing chloride', 13.5% as 'containing sulphate' and 17.5% as 'containing calcium'. 2.8% of samples did not conform with European Community limits for at least one parameter (Se, NO_2^-, Mn, Ni, Ba, F and NO_3^-). About 9% of samples had boron, nitrate or nitrite levels above the legal limit existing in individual European countries.

1. Introduction

Natural mineral water is defined as a 'microbiologically wholesome water originating in an underground water table or deposit, and emerging from a spring tapped at one or more natural or bore exits' (Council Directive 1980/777/EC and Commission Directive 1996/70/EC and 2009/54/EC), with a distinguishing and constant chemical composition. The global bottled water market reached a value of $60,938 million (115,393.5 million L) in 2006 and is forecast to increase in the future (King, 2008). Nowadays, many people prefer bottled mineral water, deeming it to be more carefully controlled, safer and healthier, and even therapeutic because of its mineral content. Oligomineral waters are considered useful for people with hyperuricemia, gout, urolithiasis and hypertension whereas calcium-rich mineral waters are useful for growing children, menopausal and pregnant women and elderly people, mainly contributing towards the daily intake of this mineral. The list recognised by the Member States of the European Union includes more than 2000 natural mineral water sources (OJEC, 2002a,b,c; OJEU, 2005, 2006; http://ec.europa.eu/food/food/labellingnutrition/water/mw_eulist_en.pdf, retrieved 19/10/09). Legal limits are fixed for elemental composition (Table 1). Although several minerals (e.g. Ca, Mg, Co, Cu, Mo, Se, Zn) are required for human health, others – such as As, Cd, Pb but also essential micronutrients when present in excessive levels – could be harmful (Pais and Jones, 1997). A mineral water can only be sold if the concentration of constituents is within the limits set by the Regulations and the maximum allowable concentrations are calculated by considering the nature of the constituent, its possible degree of toxicity and the long-term maximum daily intake. In a few cases and in some countries, specific age brackets are taken into account, e.g. some maximum limits are defined for consumption by infants in Austria, Germany and Italy.

In the last few years many studies have focused on the elemental composition of bottled and some mineral waters in individual countries – such as Nigeria (Nkono and Asubiojo, 1997), Canada (Dabeka et al., 2002), Sweden (Rosborg et al., 2005), Greece

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Table 1
Maximum allowable content (mg/L) of mineral elements in mineral water established by different European Countries, the European Community, World Health Organisation and United States Environmental Protection Agency.

Components	EC[c]	Austria[d]	Austria[a,d]	France[e]	Germany[f]	Germany[a,f]	Italy[g]	Italy[a,g]	Netherlands[h]	Spain[i]	England[j]	WHO[b,k]	US-EPA[b,l]
	2003	2006	1999	2007	2006		2003		2007		2006	2008	2009
Aluminium										(0.2)			(0.05–0.2)
Ammonium										(0.5)			
Barium	1.0	1.0		1.0	1.0		1.0		1.0	1.0	1.0	0.7	2
Boron							5.0			1.0		0.5	
Cadmium	0.003	0.003		0.003	0.003		0.003		0.003	0.003	0.003	0.003	0.005
Calcium			175										
Chlorides			50										(250)
Copper	1.0	1.0		1.0	1.0		1.0		1.0	1.0	1.0	2	1.3 (1)
Fluorides	5.0	5.0	1.5	5.0	(5.0 since 2008)	0.7	5.0	1.5	5.0	5.0	5.0	1.5	4 (2)
Fluorides declaration		1.5			1.5					1.5			
Hydrogencarbonate			550										
Lead	0.010	0.010		0.010	0.010		0.010		0.010	0.010	0.010	0.01	0.015
Magnesium			50										
Manganese	0.50	0.50		0.50	0.50	0.05	0.50		0.50	(0.05)	0.50	0.4	(0.05)
Molybdenum												0.07	
Nickel	0.020	0.020		0.020	0.050 (0.020 since 2008)		0.020		0.020	0.020	0.020	0.07	
Nitrates	50	25	10	50	50	10	45	10	50	50	50	50	10 (as N)
Nitrites	0.1	0.1	0.02	0.1	0.1	0.02	0.02		0.1	0.1	0.1	3	1 (as N)
Potassium			10										
Selenium	0.010	0.010		0.010	0.010		0.010		0.010	0.010	0.010	0.01	0.05
Sodium			20			20							
Sulphates			240			240							(250)
Thallium													0.002
Uranium						0.002						0.015	0.03
Zinc													(5)

EC = European Community; WHO = World Health Organisation; US-EPA = United States Environmental Protection Agency (US-EPA). The maximum contaminant level is given.
[a] Waters suitable for preparation of infant food.
[b] Refers to drinking waters.
[c] Commission Directive 2003/40/EC of 16/05/2003.
[d] Mineralwasser- und Quellwasserverordnung.
[e] Arrêté du 14/03/2007.
[f] Mineral- und Tafelwasserverordnung vom 01/08/84.
[g] Decreto 29/12/2003.
[h] Besluit van 6/11/2003.
[i] Real decreto 1744/2003 de 19/12/2003. Values in brackets are indicative parameters.
[j] The Natural Mineral Water, Spring Water and Bottled Drinking Water. (England) Regulation 2007.
[k] WHO (2008), no. 1/4.
[l] US-EPA, 2009. 816-F-09-004. Values in brackets are non-enforceable guidelines (National Secondary Drinking Water Regulation; NSDWR). Please refer to "References" section for full bibliographic citation.

(Soupioni et al., 2006; Karamanis et al., 2007) and Turkey (Baba et al., 2008) – or of a limited number of samples from several countries (Misund et al., 1999; Lau and Luk, 2002; Krachler and Shotyk, 2009) or simply derived from the compositional information given on bottle labels (Naddeo et al., 2008). Several studies have dealt with the influence of leaching from different packaging materials on water composition (Misund et al., 1999; Shotyk and Krachler, 2007a,b; Krachler and Shotyk, 2009).

Results for mineral waters collected in 23 countries and analysed within the context of the TRACE project (Tracing Food commodities in Europe, VI FP, Contract N. 006942) are presented in this paper. With regard to product analysis, it provides the widest overview of the chemical composition of European bottled mineral waters currently available.

2. Materials and methods

2.1. Sampling

Five hundred and seventy-one bottled mineral waters (159 in glass, 407 in PET and 5 in Tetra Pak) from different brands and sources were bought on the market in 23 European countries during 2005 and 2006 (Table 2), stored at 10–15 °C in the dark and analysed within 2 years after bottling. The geographical origin of the mineral waters was gathered from the label of each bottle and, when possible, confirmed from the EU lists (OJEU, 2005). The sampling was organised to get a widespread overview of the European market and to obtain a relatively complete geologic and geographic coverage. The unequal number of samples available in

Table 2
Mineral waters sampled for each country.

Country	Country code	No. of samples	Country	Country code	No. of samples	Country	Country code	No. of samples
Austria	A	17	France	F	32	Norway	N	4
Belgium	B	1	Germany	D	185	Poland	PL	17
Bosnia i Herzegovina	BiH	1	Great Britain	GB	34	Portugal	P	10
Croatia	HR	3	Greece	GR	2	Russia	RUS	1
Czech Republic	CZ	4	Hungary	H	9	Slovenia	SLO	3
Denmark	DK	3	Ireland	IRL	3	Spain	E	42
Finland	FIN	4	Italy	I	186	Switzerland	CH	6
			Netherlands	NL	3	Ukraine	UA	1