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Original Article

A comparative approach to the variation of natural elements in Italian bottled waters according to the national and international standard limits

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ABSTRACT

Water is essential for life and contains minerals which play an important role in human nutrition. The market of mineral water has been growing steadily over the last few years. Italy is the country with the highest production and consumption in the world. Current international drinking water regulations are not very clear, as well as being completely absent in several countries. They also present contradictions between drinking water intended for human consumption and those to be bottled.

This work focused on mineral water due to the wide public acceptance and economic interest of this product. Bottled mineral waters (371 brands) from all the Italian regions (20) were characterized by means of the physico-chemical and chemical composition (52 parameters) reported on their label by using statistical analysis. The relationships among selected variables were examined by Durov and Piper diagrams.

A comparison between the water quality composition and the standard limits fixed for both mineral and drinking water by national and international regulations EU, Italy, USEPA, Canada, Spain, CODEX, WHO) is also discussed.

The analysis shows that Italian waters are rich in natural elements that unequivocally characterise its taste and quality. A comparison of our results against the current Italian regulations for mineral waters shows that out of 371 bottled mineral water studied, only 2 have problems in terms of Ba and Pb concentration. However, when compared to the limits established by international regulations, there appear to be several contradictions.

Only 2 Italian regions out of 20 would fulfil the drinking water regulation for all the parameters where standard limits or guidance values are defined. Some elements show a clear regional dependency. Upon studying the large natural variation in concentration of the 52 parameters, it becomes evident that we know very little about the natural variation of element concentration in water as well as the health effects of most of the elements in drinking waters.

1. Introduction

The packaged waters sector is growing steadily with a growth rate that is higher than that of all the other soft drinks sectors. The worldwide consumption of packaged waters can be estimated to be around 165 billion L in 2005, which means that the rate was 25–26 L/per capita/year. The total turnover of the bottled water industry can be estimated to be around €45 billion (Beverfood, 2006).

The increase in consumption in western countries with a high income is mainly due to the increasing awareness of the health-preserving properties of water, both in its basic, hydrating function as well as a source of precious minerals.

Data in Table 1 show how the world market of bottled water in the 2006, with Italy being the highest production (12 billion L/year) and consumption (200 L/per capita/year) (Beverfood, 2006). Italian production of bottled water has increased by of 30% over the last 5 years. In Italy, there are more than three hundred brands of Italian bottled waters recognized by the EC (OJEC, 1996, 2000).

Water is necessary for life due to its natural elements which play a central role. For example, sodium is considered to be a contributory cause of dietary cancer, whereas potassium may play a protective role (Jansson, 1996). The effect of calcium is less clear as it may depend on the concentration of both sodium and potassium (Yang et al., 1997). Mineral water may represent a good source of calcium which is necessary for the maintenance of bones (Ekmekcioglu, 2000). The consumption of water with a high fluoride–silica relationship may explain the positive effect of fluoride on patients affected by bone fracture (Fabiani et al., 1999).

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Table 1
Consumption of bottled waters in the world (Beverfood, 2006)

Continents	Population		Total consumption		Per capita	
	Billion	%	Billion	%	L	Index
Western. Europe	397	*6.1*	44.5	*27.0*	112	*448*
Eastern. Europe	410	*6.3*	11.6	*7.0*	28	*112*
Total	807	*12.4*	56.1	*34.0*	70	*280*
North America	325	*5.0*	27.2	*16.5*	84	*336*
Latin America	565	*8.7*	28.0	*17.0*	50	*200*
Total	890	*13.7*	55.2	*33.5*	62	*248*
Australia &and Asia	3.646	*56.1*	39.6	*24.0*	11	*44*
Africa &and Middle East	1.157	*17.8*	14.1	*8.5*	12	*48*
Total	4.803	*73.9*	53.7	*32.5*	11	*44*
Total world	6.500		165.0		25	

Sulphite is reported as a cause of potential adverse effects on individuals (Lester, 1995). Moreover, the number of chemical contaminants identified in drinking water has grown exponentially and includes disinfection by products (DBPs) and many other compounds (Gabrielli and Gerofi, 1984; Tsezou et al., 1996; Rondeau et al., 2000; Calderon, 2000; Rook, 1974; USEPA, 2000).

Bottled water is associated with naturalness and perceived by many to taste better, to have fewer impurities, and to confer higher social status on the consumer than tap water (Allen et al., 1989; Falahee and MacRae, 1995; Saad et al., 1998). The commercialization of processed tap water has been authorized by many countries; this may attract unscrupulous manufacturers toward illegal activities such as bottling tap water and selling it as mineral water. Worry regarding tap water concerns the mineral content (Crawford and Gardner, 1968; Gibson et al., 1987), the level of contaminants, as well as the microbiological quality. The quality of Italian mineral water was questioned and a comparative study between mineral and tap waters demonstrated the lack of significant difference in terms of quality (D'Ascenzo et al., 1997; Versari et al., 2002). Variation of natural elements in European bottled mineral waters and its health effects was investigated by Misund et al. (1999). Other interesting studies evaluate the drinking water quality from Kuwait (Al Fraij et al., 1999), Canada (Gibson et al., 1987), Turkey (Güler, 2007a, b), Nigeria (Nkono and Asubiojo, 1997) and Egypt (Saleh et al., 2001). In any case, the results of these studies were obtained from the analyses of few samples of the National sources.

In this study, 371 Italian bottled mineral waters were characterized by a statistical analysis using the physico-chemical and chemical composition reported on their label. Attempts to differentiate the mineral waters according to their origin and composition was made. The standard limits established by Italian and main international regulations for selected parameters are reported and investigated.

2. Material and methods

The physico-chemical and chemical composition reported on the label of 371 Italian bottled mineral waters were used as data for this study. Brand name, spring, location, laboratory and the data of chemical analysis for each considered bottled water are listed in the Appendix, divided into 20 groups based on the distribution in the Italian regions. The data are representative of all Italian bottled waters. Fig. 1 shows the geographic distribution of the springs in each region, with 46% of the bottled waters (170 brands) being in Northern Italy while only 15% (57 brands) in the South.

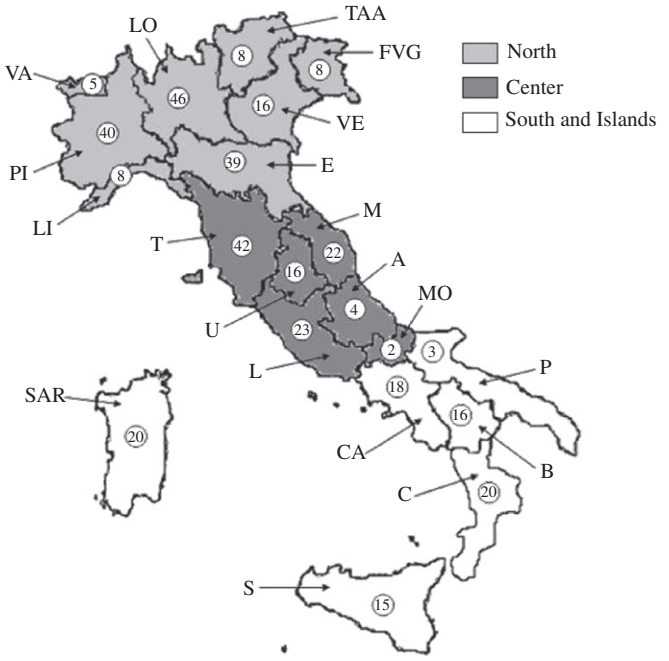

Fig. 1. Regional distribution of the Italian bottled mineral waters. A, Abruzzi; B, Basilicata; C, Calabria, CA, Campania; E, Emilia Romagna; FVG, Friuli Venezia Giulia; L, Latium; LI, Liguria; LO, Lombardy; M, Marches; MO, Molise; P, Apulia; PI, Piedmont; S, Sicily; SAR, Sardinia; T, Toscany; TAA, Trentino Alto Adige; U, Umbria; VA, Valle D'Aosta; VE, Veneto.

Fifty-two physico-chemical and chemical parameters were considered (Ag, Al, As, B, Ba, Br, Ca, Cd, Cl, CN, CO, CO_2, CO_3, conductivity, Cr, Cs, Cu, C_6H_5OH density, F, Fe, H_2S, H_3BO_3, hardness, HCO_3, Hg, I, K, La, Li, Mg, Mn, N, Na, NH_4, Ni, NO_2, NO_3, O_2, P_2O_5, Pb, pH, PO_4, S, Se, SiO_2, Sn, SO_4, Sr, TDS, temperature of spring, Zn). These determinations were carried out and certified by the official analysis laboratories, and their accuracy and precision is not questioned in this study. Routine analysis of mineral water is carried out by each company on a daily basis, whereas a complete analytical control is scheduled, at least, with annual frequency. On the other hand, the labels remain valid for a period of 5 years fixed by DL 12/12/1992 n. 54 and DL 25/01/1992 n. 96 105.

The analysis is based on an initial characterisation of the quality of the bottled waters by calculating the min, max, 75th percentile and mean values is more appropriate for each parameter. For parameters where the minimum was below the detection limit, the value of the detection limit was used for the calculation, giving a conservative estimate. The quality of the waters are discussed through Piper and Durov diagrams (Durov, 1948; Piper, 1944). A statistical analysis was carried out on the variation of the main natural elements presented in terms of concentration and spatial distribution.

The most representative regulations and guidelines in the world were also taken into consideration in order to compare the quality of Italian bottled waters. These included the Directive 2003/40/EC of the European Community (EU), the Real Decreto 140/2003 dated 7 February for Spain (E) and the National Primary and Secondary Drinking Water Regulations (USEPA, 2006) developed by the Environmental Protection Agency of the United States