



Original / Otros

The calcium concentration of public drinking waters and bottled mineral waters in Spain and its contribution to satisfying nutritional needs

Isidro Vitoria¹, Francisco Maraver², Cíntia Ferreira-Pêgo^{3,4}, Francisco Armijo², Luis Moreno Aznar⁵ and Jordi Salas-Salvadó^{3,4}

¹Nutrition and Metabolopathies Unit. Hospital La Fe. Valencia. Spain. ²Professional School of Medical Hydrology. Faculty of Medicine. Complutense University. Madrid. Spain. ³Human Nutrition Unit. Sant Joan University Hospital. Reus. Faculty of Medicine and Health Sciences. IISPV (Pere Virgili Health Research Institute). Department of Biochemistry and Biotechnology. Rovira i Virgili University. Reus. Spain. ⁴CIBERobn (Biomedical Research Centre in Physiopathology of Obesity and Nutrition). Carlos III Institute of Health. Madrid. Spain. ⁵GENUD (Growth, Exercise, Nutrition and Development) Research Group. Faculty of Health Sciences. University of Zaragoza. Spain.

Abstract

Introduction: A sufficient intake of calcium enables correct bone mineralization. The bioavailability of calcium in water is similar to that in milk.

Objective: To determine the concentration of calcium in public drinking water and bottled mineral water.

Methods: We used ion chromatography to analyse the calcium concentrations of public drinking waters in a representative sample of 108 Spanish municipalities (21,290,707 people) and of 109 natural mineral waters sold in Spain, 97 of which were produced in Spain and 12 of which were imported.

Results: The average calcium concentration of public drinking waters was 38.96 ± 32.44 mg/L (range: 0.40-159.68 mg/L). In 27 municipalities, the water contained 50-100 mg/L of calcium and in six municipalities it contained over 100 mg/L. The average calcium concentration of the 97 Spanish natural mineral water brands was 39.6 mg/L (range: 0.6-610.1 mg/L). Of these, 34 contained 50-100 mg/L of calcium and six contained over 100 mg/L. Of the 12 imported brands, 10 contained over 50 mg/L. Assuming water consumption is as recommended, water containing 50-100 mg/L of calcium provides 5.4-12.8% of the recommended intake of calcium for children aged one to thirteen, up to 13.6% for adolescents, 5.8-17.6% for adults, and up to 20.8% for lactating mothers. Water with 100-150 mg/L of calcium provides 10-31% of the recommended dietary allowance, depending on the age of the individual.

Discussion: Public drinking water and natural mineral water consumption in a third of Spanish cities can be considered an important complementary source of calcium.

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Key words: Calcium. Public drinking water. Natural mineral water. Water softening. Nutritional requirements.

Correspondence: Isidro Vitoria.
Nutrition and Metabolopathies Unit.
Hospital La Fe.
Bulevar sur, s/n. 46021 Valencia. Spain.
E-mail: vitoria_isi@gva.es

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CALCIO EN EL AGUA DE CONSUMO PUBLICO Y AGUAS MINERALES NATURALES EN ESPAÑA Y SU CONTRIBUCION EN CUBRIR LAS NECESIDADES NUTRICIONALES

Resumen

Introducción: Una adecuada ingesta de calcio condicio-
na una buena mineralización ósea.

Objetivo: Determinar el contenido en calcio en aguas de
bebida.

Métodos: En 2012 se analizaron las concentraciones de calcio, por cromatografía iónica, de aguas de consumo público de una muestra representativa de 108 poblaciones españolas que abastecen a 21.290.707 personas, así como de 109 aguas minerales naturales comercializadas en España (97 españolas y 12 importadas).

Resultados: La concentración media de calcio en aguas de consumo público fue de $38,96 \pm 32,44$ mg/L (rango: 0,40-159,68 mg/L). En 27 poblaciones el agua contiene entre 50-100 mg/L de calcio y en 6 fue superior a 100 mg/L. La concentración media de calcio de las 97 marcas españolas de aguas fue de 39,6 mg/L (rango: 0,6-610,1 mg/L), 34 de ellas contenían entre 50-100 mg/L de calcio, mientras que en 6 de ellas más de 100 mg/L. De las 12 marcas importadas, 10 contenían más de 50 mg/L. Asumiendo una ingesta de agua recomendada, si el agua contiene entre 50-100 mg/L de calcio, ésta aportaría entre 5,4-12,8% de la ingesta de calcio recomendada para los niños de 1-13 años, hasta el 13,6% en adolescentes, entre 5,8-17,6% en adultos, y hasta el 20,8% en madres lactantes. El agua conteniendo 100-150 mg/L de calcio aportaría entre 10-31% de las recomendaciones según la edad.

Discusión: El agua de consumo público de un tercio de ciudades españolas y de aguas minerales naturales puede ser considerada como una fuente complementaria importante de calcio ingerido.

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Palabras clave: Calcio. Agua de bebida. Agua mineral natural. Ablandamiento del agua. Necesidades nutricionales.

Abbreviations

PDW: Public drinking waters.
NMW: Natural mineral waters.
EU: European Union.
EFSA: European Food Safety Agency.
IOM: Institute of Medicine.
RDA: Recommended Dietary Allowances.
PTH: Parathyroid hormone.

Introduction

Sufficient calcium consumption is important for maintaining correct bone health and preventing osteoporosis^{1,2}. It may also help to prevent obesity³, insulin resistance⁴ and other chronic illnesses associated with the immune and neuromuscular system⁵.

The United States Institute of Medicine (IOM) recently set the recommended dietary allowances (RDA) for calcium. These ranges from 700 to 1,000 mg/day for children aged between one and nine and from 1,000 to 1,300 mg/day for adolescents and adults⁶ (table I). These daily allowances are not met by the entire Spanish population⁷, especially at two key stages of bone metabolism: infancy and menopause. Representative studies of the Spanish population found that the calcium consumptions of 76.7% of children of school age⁸ and 79.6% of menopausal women⁹ were insufficient.

Where recommended daily intake is not satisfied via food consumption, medical calcium supplements may be taken¹⁰. However, administering these supplements involves practical difficulties¹¹ as well as cardiovascular risks¹² that have not yet been fully determined.

For this reason, in recent years much interest has been generated in calcium-enriched foods (milk, yoghurt, cereals, fruit juices, etc.) and other sources of calcium. The calcium present in drinking water should therefore also be considered since its bioavailability from drinking water is similar to that from dairy products¹³. When recommendations regarding types of drinking water are reviewed, however, their calcium concentrations are rarely considered important¹⁴. For example, neither Spanish¹⁵ nor European¹⁶ regulations on public drinking water (PDW) refer to the concentration of this mineral. The Codex rule¹⁷ for natural mineral waters (NMW) also does not mention calcium concentration and Spanish and European regulations on bottled water only indicate that these beverages can be described as calcic if they contain over 150 mg/L of calcium.

Few studies have determined the calcium concentration of Spanish PDW and NMW^{18,19}. Even fewer studies have analysed how frequent and continuous consumption of calcium may prevent osteoporosis or other chronic illnesses²⁰. In this study, therefore, we analyse the calcium concentration of the PDW and NMW consumed in Spain and evaluate their contribution to the recommended dietary intake of this mineral.

Material and methods

During 2012 we selected PDW samples from 108 of the 144 Spanish cities with a population of over 50,000 inhabitants (total population of 21,290,707, or 45.3% of the total Spanish population). These cities were selected at random so that they would represent all Spanish geographical regions. The number of inhabitants in each city was taken from the de jure population figures by municipalities recorded for 2012 by the Spanish Statistical Office²¹. In each of the cities studied, we collected three two-litre samples of PDW in opaque plastic bottles after allowing the water to flow from the tap for at least three minutes. These samples were taken from private homes or public establishments that were without domestic filters or reverse osmosis systems. Similarly, three bottles (with different bottling dates) of 97 Spanish brands of NMW and 12 brands of imported NMW were acquired from supermarkets or grocery stores in various Spanish cities. From the full list of 151 Spanish NMW recognized by the EU²², we selected 97 samples of the most consumed Spanish brands that also represented the geographical regions with the most springs. The locations of the springs of the NMW are shown in figure 1. For both types of sample (PDW and NMW), the bottles were stored in the dark and at ambient temperature until they were analysed.

Calcium concentrations were determined by ion chromatography (EPA method 300.7) using the Dionex DX-120 ion chromatograph with Fluka 39865 standard calibration solution. Sample calibrations and concentrations were obtained using PeakNet 5.10d

Age	RDA (mg/day)	UL (µg/day)
0–6 months	200 (*)	1,000
6–12 months	260 (*)	1,500
1–3 years	700	2,500
4–8 years	1,000	2,500
9–13 years	1,300	3,000
14–18 years	1,300	3,000
14–18 years		
Pregnant/ Lactating mothers	1,300	3,000
19–50 years	1,000	2,500
19–50 years		
Pregnant/ Lactating mothers	1,000	2,500
51–70 years		
(Men)	1,000	2,000
51–70 years		
(Women)	1,200	2,000
> 70 years	1,200	2,000

(*) Adequate intake.

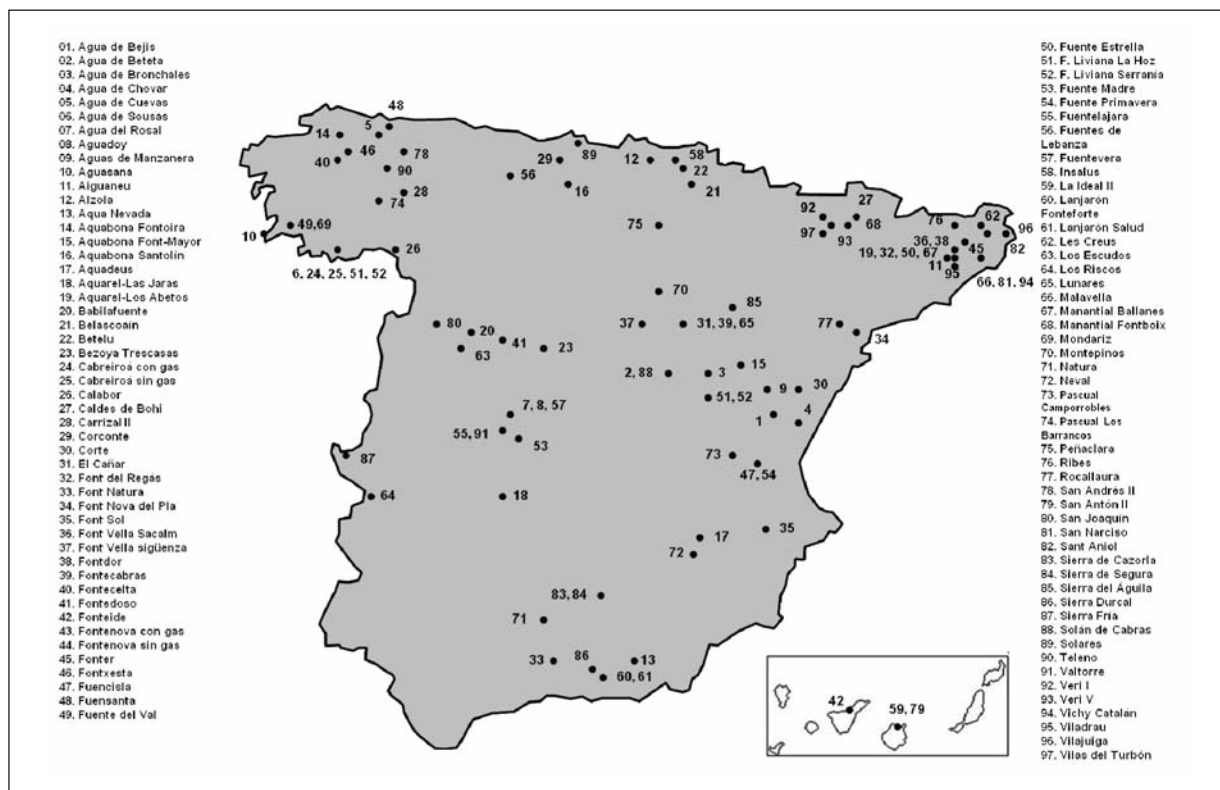


Fig. 1.—Sources of Spanish natural mineral waters.

—SE and the 4110-B method recommended by the American Public Health Association, the American Water Works Association, and the Water Environment Federation²³.

Results

Table II shows the average calcium concentration in the PDW of the 108 Spanish cities studied. The average calcium concentration for all cities was 38.96 ± 32.44 mg/L, ranging from 0.40 mg/L in San Vicente del Raspeig to 159.68 mg/L in Girona.

In 48 of the 108 cities, the calcium concentration was below 25 mg/L. In 27 cities, it was between 25 and 50 mg/L and in another 27 cities, which supply 3,726,377 people it was between 50 and 100 mg/L. Finally, in 6 other cities, home to almost one million people, the calcium concentration was over 100 mg/L (table III).

Figure 2 shows the Spanish cities where the calcium concentrations in the PDW were determined.

Tables IV and V show the calcium concentrations in mg/L of the 109 NMW brands studied (97 Spanish brands and 12 imported brands, respectively). The average calcium concentration of the Spanish NMW brands was 39.6 mg/L and the concentration ranged from 0.6 mg/L (Aguasana®) to 610.1 mg/L (Agua de Manzanera®). Of the Spanish brands, 57 (58.76%)

contained less than 50 mg/L, 34 (35.05%) contained between 50 and 100 mg/L, and 6 (6.19%) contained over 100 mg/L. The average calcium concentration of the imported NMW was 93.52 ± 47.11 mg/L, with a maximum of 158.4 mg/L and a minimum of 14 mg/L. Of the 12 brands studied, 10 had a calcium concentration of over 50 mg/L and four had a calcium concentration of over 140 mg/L.

Discussion

Consuming the recommended dietary allowances for calcium is important for achieving better bone mineral density. Because of their high calcium content and high bioavailability of around 30%, the main dietary sources of calcium are milk and dairy products. The high calcium content in milk and its derivatives is similar to that of water. In an experimental study, Couzy et al.¹³ compared the bioavailability of calcium from cow's milk and calcium-rich waters (467 mg/L) in 10 young women aged between 21 and 36. The rates of absorption were $25.0 \pm 6.7\%$ for milk and $23.8 \pm 4.8\%$ for water. In another experimental study, Bacciottini et al.²⁵ observed that the absorption of a calcium content of 3.18 mmol from water was $23.15 \pm 4.06\%$, but this percentage does not appear to be constant. The authors of a systematic review and meta-analysis also observed that in waters with a lower

Table II
Average calcium concentration in public drinking water according Spanish regions

Nº	Autonomous community	Cities	Population	Average calcium concentration (mg/L)
83	Andalusia	Alcalá de Guadaíra	70,155	25.59 ± 2.13
49	Andalusia	Algeciras	116,209	16.71 ± 1.82
44	Andalusia	Cádiz	126,766	66.38 ± 5.24
76	Andalusia	Chiclana de la Frontera	77,293	63.67 ± 6.07
12	Andalusia	Córdoba	328,428	14.27 ± 1.23
45	Andalusia	Dos Hermanas	122,943	24.02 ± 2.34
64	Andalusia	El Puerto Santa María	87,696	59.67 ± 5.67
81	Andalusia	Fuengirola	71,482	45.94 ± 3.24
19	Andalusia	Granada	234,325	27.53 ± 2.21
25	Andalusia	Jerez de la Frontera	207,532	58.29 ± 5.67
87	Andalusia	La Línea de la Concepción	64,595	18.57 ± 1.87
6	Andalusia	Málaga	568,305	31.84 ± 3.23
42	Andalusia	Marbella	134,623	27.10 ± 2.08
57	Andalusia	San Fernando	96,366	65.94 ± 5.84
86	Andalusia	Sanlúcar de Barrameda	65,805	64.29 ± 7.42
4	Andalusia	Sevilla	703,206	23.95 ± 2.16
106	Aragon	Huesca	52,059	65.5 ± 5.87
5	Aragon	Zaragoza	674,317	10.85 ± 1.21
68	Asturias	Avilés	84,242	0.88 ± 0.23
15	Asturias	Gijón	277,554	35.36 ± 3.45
21	Asturias	Oviedo	224,005	43.06 ± 4.32
108	Asturias	Siero	51,181	33.04 ± 5.23
8	Balearic Islands	Palma	401,270	101.16 ± 11.02
74	Canary Islands	Arona	78,614	6.81 ± 2.21
97	Canary Islands	Arrecife	59,127	18.67 ± 2.87
9	Canary Islands	Palmas de Gran Canaria (Las)	381,847	44.64 ± 3.54
105	Canary Islands	San Bartolomé de Tirajana	52,161	20.62 ± 2.32
39	Canary Islands	San Cristóbal de La Laguna	150,661	4.11 ± 0.65
22	Canary Islands	Santa Cruz de Tenerife	222,417	34.14 ± 3.21
90	Canary Islands	Santa Lucía de Tirajana	63,637	19.01 ± 1.76
54	Canary Islands	Telde	100,015	10.88 ± 1.07
32	Cantabria	Santander	182,700	73.62 ± 7.01
101	Cantabria	Torrelavega	55,947	54.96 ± 5.32
99	Castille and Leon	Ávila	56,855	9.82 ± 0.87
34	Castille and Leon	Burgos	178,966	15.86 ± 1.32
43	Castille and Leon	León	134,305	30.11 ± 2.98
37	Castille and Leon	Salamanca	155,619	11.98 ± 1.65
13	Castille and Leon	Valladolid	317,864	34.06 ± 3.42
102	Castille La Mancha	Cuenca	55,866	72.19 ± 7.13
63	Castille La Mancha	Talavera de la Reina	88,856	27.97 ± 2.84
71	Castille La Mancha	Toledo	82,291	11.91 ± 1.76
23	Catalonia	Badalona	219,547	50.72 ± 7.89
2	Catalonia	Barcelona	1,621,537	37.18 ± 5.34
93	Catalonia	Castelldefels	62,080	71.01 ± 9.04
98	Catalonia	Cerdanyola del Vallés	58,747	46.37 ± 5.56
65	Catalonia	Cornellà de Llobregat	86,519	82.34 ± 10.23
92	Catalonia	El Prat de Llobregat	63,418	45.79 ± 5.67
58	Catalonia	Girona	96,188	159.68 ± 18.76
96	Catalonia	Granollers	60,658	47.82 ± 5.34
16	Catalonia	Hospitalet de Llobregat	257,038	100.12 ± 12.12
41	Catalonia	Lleida	135,919	44.73 ± 5.39
77	Catalonia	Manresa	76,558	10.79 ± 9.87
46	Catalonia	Mataró	121,722	67.86 ± 7.89
104	Catalonia	Mollet del Vallès	52,484	53.1 ± 4.56
52	Catalonia	Reus	107,118	101.6 ± 18.23
80	Catalonia	Rubí	72,987	49.94 ± 7.45
69	Catalonia	Sant Boi de Llobregat	82,428	93.31 ± 8.76
47	Catalonia	Santa Coloma de Gramenet	119,717	51.18 ± 4.67
24	Catalonia	Tarrasa	210,941	88.78 ± 7.98
91	Catalonia	Viladecans	63,489	65.77 ± 6.98
94	Valencia	Alcoy	61,552	19.24 ± 2.56

Table II (cont.)
Average calcium concentration in public drinking water according Spanish regions

Nº	Autonomous community	Cities	Population	Average calcium concentration (mg/L)
11	Valencia	Alicante	334,757	46.26 ± 4.65
82	Valencia	Benidorm	71,034	65.26 ± 6.67
33	Valencia	Castellón de la Plana	180,005	73.10 ± 7.76
20	Valencia	Elche	230,112	40.92 ± 5.21
73	Valencia	Gandía	80,020	33.93 ± 3.66
67	Valencia	Orihuela	86,164	2.77 ± 1.23
89	Valencia	Paterna	64,023	146.5 ± 13.78
85	Valencia	Sagunto	66,070	93.62 ± 12.45
103	Valencia	San Vicente del Raspeig	53,126	0.40 ± 0.12
75	Valencia	Torrent	78,543	84.05 ± 7.56
53	Valencia	Torreveja	101,792	50.1 ± 5.23
3	Valencia	Valencia	814,208	88.71 ± 8.65
107	Valencia	Vila-real	51,205	114.68 ± 13.32
40	Extremadura	Badajoz	148,334	16.1 ± 2.13
60	Extremadura	Cáceres	93,131	15.64 ± 2.13
100	Extremadura	Mérida	56,395	43.25 ± 4.12
79	Galicia	Ferrol	74,273	5.60 ± 0.89
17	Galicia	La Coruña	246,056	9.4 ± 0.96
56	Galicia	Lugo	96,678	12.8 ± 1.03
51	Galicia	Orense	107,742	10.9 ± 1.45
59	Galicia	Santiago de Compostela	95,092	7.30 ± 0.67
14	Galicia	Vigo	297,332	2.10 ± 0.12
38	La Rioja	Logroño	152,107	96.97 ± 9.43
27	Madrid	Alcalá de Henares	204,574	13.19 ± 1.23
50	Madrid	Alcobendas	109,104	13.39 ± 1.32
35	Madrid	Alcorcón	167,967	10.03 ± 1.02
62	Madrid	Coslada	90,280	10.47 ± 1.05
29	Madrid	Fuenlabrada	197,836	10.15 ± 1.21
36	Madrid	Getafe	167,164	11.31 ± 1.46
66	Madrid	Las Rozas	86,340	10.49 ± 2.32
30	Madrid	Leganés	186,066	10.28 ± 1.03
1	Madrid	Madrid	3,255,944	13.94 ± 1.23
84	Madrid	Majadahonda	68,110	10.24 ± 0.98
26	Madrid	Móstoles	206,478	10.17 ± 1.43
70	Madrid	Pozuelo de Alarcón	82,428	10.08 ± 1.08
78	Madrid	San Sebastián Reyes	75,912	11.55 ± 1.13
48	Madrid	Torrejón de Ardoz	118,162	12.59 ± 1.34
61	Murcia	Lorca	91,906	6.32 ± 0.81
88	Murcia	Molina de Segura	64,065	1.57 ± 0.88
7	Murcia	Murcia	436,870	0.70 ± 0.41
28	Navarre	Pamplona	198,491	18.57 ± 1.76
55	Basque country	Baracaldo	98,460	32.8 ± 3.45
10	Basque country	Bilbao	354,860	31.59 ± 4.32
72	Basque country	Getxo	80,770	39.9 ± 5.67
95	Basque country	Irún	60,951	27.55 ± 3.42
31	Basque country	San Sebastián	185,357	22.53 ± 2.34
18	Basque country	Vitoria	235,661	50.43 ± 5.53

Data expressed as means ± SD.

calcium concentration (< 100 mg/L), the percentage absorbed was greater (47.5%)²⁶. In summary, the absorption coefficient of calcium in water with respect to the absorption coefficient of calcium in milk ranges from 1.129 ± 0.056 to 0.985 ± 0.070. According to the bibliography, therefore, calcium in water is absorbed at least as easily as the calcium in dairy products²⁷. Also, according to a review conducted in 2006, as occurs with other food sources of calcium, the calcium in

water is absorbed almost 20% more if it is consumed along with other foods than if it is consumed on its own²⁸.

People who do not consume sufficient calcium may be given supplements usually to be taken once a day. However, as supplements with large quantities of calcium may inhibit parathyroid hormone (PTH) and bone resorption²⁹ more intensely but for less time, it is recommended that the doses be broken up in order to

Table III
Calcium concentration distribution in public drinking water, according to the number of regions and inhabitants analyzed

Average calcium concentration (mg/L)	Number of regions (n = 108)	Number of inhabitants (n = 21,290,707)
< 25	48	10,500,978
25-50	27	6,086,510
50-100	27	3,726,377
> 100	6	976,842

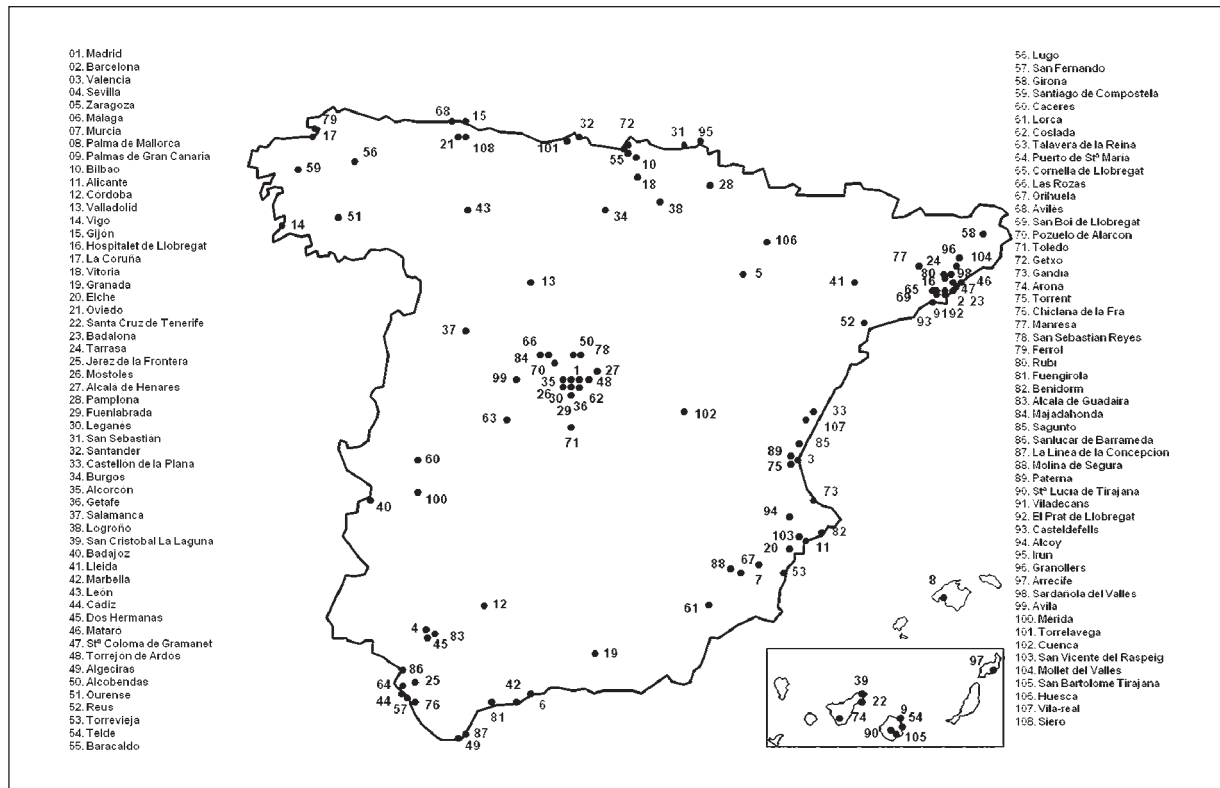


Fig. 2.— Spanish cities whose calcium concentrations of public drinking waters have been analyzed.

achieve a more sustained inhibition of bone resorption^{30,31}. Water consumed throughout the day can therefore be a significant food alternative to satisfy requirements for this mineral³². In a six-month randomized double-blind test conducted on postmenopausal women, calcium-rich drinking water was found to have a positive effect on the biochemical parameters associated with bone metabolism³³. In the EPIDOS cohort, a 100 mg per day increase in calcium consumption from drinking water in women aged over 75 was associated with a 0.5% increase in bone mineral density³⁴. However, we should also mention that people with osteoporosis treated with bisphosphonates should take these drugs with water that is low in calcium since a tendency to form complexes with divalent cations (calcium, magnesium, iron, etc.) and a reduction in the absorption of the bisphosphonates have been reported³⁵.

The calcium concentrations of the PDW vary greatly and basically depend on the type of bedrock on which the aquifer lies (if the water is from a subterranean source) or on the origin of the water (if the water is from an above-ground source).

In a review of the mineral content of the PDW of 44 cities in the United States³⁶, the average calcium concentration in 36 cities whose PDW source was above ground was 34 ± 21 mg/L and in the eight cities whose source was subterranean it was 52 ± 24 mg/L. Calcium concentration ranged from 2 to 85 mg/L. In a descriptive transversal study of PDW in Canada, the average calcium concentration was 48.8 mg/L and the calcium concentration ranged from 1 to 135 mg/L. When the authors of that study also analysed the calcium concentration of PDW in the United States, they found that the average concentration was 50.6 mg/L and that the concentration ranged from 8.3 to 131 mg/L³⁵.

Table IV
Calcium content of 97 Spanish brands of natural mineral waters

Nº	Brand	Spring	Region	Bottle	Calcium in bottle label	Average calcium concentrations (mg/L)
1	Agua de Bejis®	Los Cloticos- Bejis	Bejis (Castellón)	Plastic 1,500 ml	49.7	45.8 ± 4.2
2	Agua de Beteta®	Fuente del Arca	Beteta (Cuenca)	Plastic 1,500 ml	66	65.4 ± 5.6
3	Agua de Bronchales®	Bronchales 3	Bronchales (Teruel)	Plastic 2,000 ml	3	3.2 ± 1.1
4	Agua de Chovar®	Fuente Barranco Carbón	Chovar (Castellón)	Plastic 2,000 ml	19	19.4 ± 2.4
5	Agua de Cuevas®	Fuente de Cuevas	Aller (Asturias)	Plastic 1,500 ml	45.6	51.1 ± 7.12
6	Agua de Sousas®	Sousas II	Verín (Ourense)	Plastic 1,500 ml	3.1	3.6 ± 0.5
7	Agua del Rosal®	Agua del Rosal	Calera y Chozas (Toledo)	Plastic 1,500 ml	66.2	58.8 ± 5.3
8	Aguadoy®	Aguadoy	Calera y Chozas (Toledo)	Plastic 2,000 ml	30.9	31.9 ± 2.8
9	Aguas de Manzanera®	El Salvador	Manzanera (Teruel)	Plastic 5,000 ml	705.4	610.1 ± 25.2
10	Aguasana®	A Granxa/La Granja	Baiona (Pontevedra)	Plastic 1,500 ml	0.5	0.6 ± 0.6
11	Aiguaneu®	Aiguaneu	Espilneves (Girona)	Plastic 1,500 ml	44.8	36.8 ± 3.8
12	Alzola®	Alzola	Elgoibar (Guipúzcoa)	Plastic 1,500 ml	61	59.1 ± 5.8
13	Aqua Nevada®	Aqua Nevada	El Tesorillo, Albuñán (Granada)	Plastic 1,500 ml	13	15.1 ± 1.2
14	Aquabona Fontoira®	Fontoira	Cospeito (Lugo)	Plastic 1,500 ml	42.1	41.2 ± 3.7
15	Aquabona Fuen-Mayor®	Fuen-Mayor	Cañizar del Olivar (Teruel)	Plastic 1,500 ml	75.6	76.2 ± 8.6
16	Aquabona Santolín®	Santolín	Quintanaurria (Burgos)	Plastic 1,500 ml	90.3	88 ± 8.2
17	Aquadeus®	Fuente Arquillo	El Robledo (Albacete)	Plastic 1,500 ml	71.5	69.8 ± 6.7
18	Aquarel-Las Jaras®	Las Jaras	Herrera del Duque (Badajoz)	Plastic 1,500 ml	1.9	2.3 ± 0.8
19	Aquarel-Los Abetos®	Los Abetos	Arbúcies (Girona)	Plastic 1,500 ml	34	29.5
20	Babilafuente®	Antigua Fuente del Caño	Babilafuente (Salamanca)	Glass 1,000 ml	47.7	49.7 ± 5.5
21	Belascoaín®	Belascoaín	Belascoaín (Navarra)	Plastic 1,500 ml	243	189 ± 12.8
22	Betelu®	Ama-Iturri	Betelu (Navarra)	Plastic 1,500 ml	92	74.1 ± 8.3
23	Bezoya Trescasas®	Bezoya Trescasas	Trescasas (Segovia)	Plastic 1,500 ml	4	6.6 ± 0.8
24	Cabreiroá con gas®	Cabreiroá	Verín (Ourense)	Glass 750 ml	22	20.4 ± 2.5
25	Cabreiroá sin gas®	Cabreiroá	Verín (Ourense)	Plastic 1,500 ml	9.5	9.6 ± 1.2
26	Calabor®	Calabor	Pedralba de la Pradería (Zamora)	Glass 500 ml	5.1	6.8 ± 1.5
27	Caldes de Bohi®	Font del Bou	Barruera (Lleida)	Plastic 1,500 ml	4	1.7 ± 0.6
28	Carrizal II®	Carrizal II	Cuadros (León)	Plastic 1,500 ml	38	39.6 ± 2.8
29	Corconte®	Balneario de Corconte	Soncillo (Burgos)	Plastic 1,500 ml	16	13.9 ± 1.6
30	Cortes®	Penyagolosa	Cortes de Arenoso (Castellón)	Plastic 1,500 ml	80.5	87.6 ± 7.6
31	El Cañar®	Cañar	Jaraba (Zaragoza)	Plastic 1,500 ml	96.1	90.1 ± 9.7
32	Font del Regàs®	Font del Regàs	Arbuices (Girona)	Plastic 8,000 ml	36.2	31.6 ± 5.8
33	Font Natura®	Font Natura	Loja (Granada)	Plastic 1,500 ml	70.9	62.7 ± 6.7
34	Font Nova del Pla®	Font Nova del Pla	Aiguamúrcia (Tarragona)	Plastic 1,500 ml	74	73.2 ± 7.1
35	Font Sol®	Aguas de Sierra	La Font de la Figuera (Valencia)	Plastic 1,500 ml	120.3	114.1 ± 13.7
36	Font Vella Sacalm®	Font Sacalm	Sant Hilari Sacalm (Girona)	Plastic 5,000 ml	38.5	32.2 ± 3.6
37	Font Vella Sigüenza®	Sigüenza	Sigüenza (Guadalajara)	Plastic 1,500 ml	82.8	80 ± 7.6
38	Fontdor®	Fontdor	Sant Hilari Sacalm (Girona)	Plastic 5,000 ml	26.4	24.2 ± 6.2
39	Fontecabras®	Fontecabras	Jaraba (Zaragoza)	Plastic 1,500 ml	92.3	86.6 ± 8.7
40	Fontecelta®	Fontecelta	Sarriá (Lugo)	Plastic 1,500 ml	21.3	18.2 ± 1.9
41	Fontedoso®	Fontedoso	El Oso (Ávila)	Plastic 5,000 ml	32.1	27.6 ± 2.8
42	Fonteide®	Fonteide	La Orotava (Santa Cruz de Tenerife)	Plastic 500 ml	6.4	6.8 ± 0.9
43	Fontenova con gas®	Fontenova	Verín (Ourense)	Glass 1,000 ml	12.8	10.2 ± 1.2
44	Fontenova sin gas®	Fontenova	Verín (Ourense)	Glass 1,000 ml	6.5	11.6 ± 1.8
45	Fonter®	Fonter	Amer (Girona)	Plastic 1,250 ml	32	34.3 ± 3.9
46	Fontxesta®	Fontxesta	Láncara (Lugo)	Plastic 5,000 ml	6.2	9.2 ± 1.1
47	Fuencisla®	Fuencisla	Requena (Valencia)	Plastic 1,500 ml	86.1	80.2 ± 7.8
48	Fuensanta®	Fuensanta de Buyer	Nava (Asturias)	Plastic 1,500 ml	69	65.6 ± 5.4
49	Fuente del Val®	Fuente del Val 2	Mondariz (Pontevedra)	Plastic 1,500 ml	17.8	14.2 ± 1.8
50	Fuente Estrella®	Fuente Estrella	Arbúcies (Girona)	Plastic 1,500 ml	25.3	25.4 ± 2.9
51	Fuente Liviana®	Arroyo de la Hoz	Huerta del Marquesado (Cuenca)	Glass 1,000 ml	66.9	52.9 ± 5.0
52	Fuente Liviana®	Serranía I	Huerta del Marquesado (Cuenca)	Plastic 2,000 ml	65.4	58.4 ± 5.2
53	Fuente Madre®	Fuente Madre	Los Navalmares (Toledo)	Plastic 1,500 ml	67.8	66.2 ± 6.4
54	Fuente Primavera®	Fuente Primavera	Requena (Valencia)	Plastic 1,500 ml	88.7	81.3 ± 7.9
55	Fuentelajara®	Fuentelajara	Belvis de la Jara (Toledo)	Plastic 5,000 ml	21.6	22.7 ± 2.5
56	Fuentes de Lebanza®	La Cueva	Lebanza (Palencia)	Plastic 1,500 ml	37.8	39.6 ± 3.8

Table IV (cont.)
Calcium content of 97 Spanish brands of natural mineral waters

Nº	Brand	Spring	Region	Bottle	Calcium in bottle label	Average calcium concentrations (mg/L)
57	Fuentevera®	Fuentevera	Calera y Chozas (Toledo)	Plastic 5,000 ml	8.2	7.3 ± 0.9
58	Insalus®	Insalus	Lizarza (Gipuzkoa)	Plastic 1,500 ml	157.3	154
59	La Ideal II®	La Ideal II (El Rapador)	Firgas (Las Palmas)	Glass 750 ml	58.2	57.7 ± 5.4
60	Lanjarón Fonteforte®	Fonteforte	Lanjarón (Granada)	Glass 500 ml	41.6	50 ± 5.8
61	Lanjarón Salud®	Salud	Lanjarón (Granada)	Plastic 1,500 ml	27.2	27.4 ± 2.8
62	Les Creus®	Les Creus	MaÇanet de Cabrenys (Girona)	Glass 1,000 ml	28.6	31.5 ± 3.6
63	Los Escudos®	Montalvo V	Aldeatejada (Salamanca)	Plastic 1,500 ml	41	39.8 ± 5.1
64	Los Riscos®	Los Riscos de la Higüela	Aburquerque (Badajoz)	Plastic 1,500 ml	2.9	2.1 ± 0.3
65	Lunares®	Lunares	Jaraba (Zaragoza)	Plastic 1,500 ml	100.4	89.9 ± 8.8
66	Malavella®	Malavella	Caldes de Malavella (Girona)	Glass 750 ml	-	12.4 ± 1.2
67	Manantial Ballanes®	Ballanes	Arbúcies (Girona)	Plastic 50 ml	54.4	42.4 ± 4.8
68	Manantial Fontboix®	Fonboix	Barruera (Lleida)	Plastic 2,000 ml	6.8	7.9 ± 1.2
69	Mondariz®	Mondariz IV	Mondariz (Pontevedra)	Plastic 1,500 ml	9.3	7.4 ± 0.8
70	Montepinos®	Montepinos	Almazán (Soria)	Plastic 1,500 ml	93.8	77.6 ± 7.8
71	Natura®	Natura	Los Villares (Jaén)	Plastic 1,500 ml	39	44.9 ± 4.8
72	Neval®	Neval	Moratalla (Murcia)	Plastic 1,500 ml	41.1	46.6 ± 4.2
73	Pascual Nature Camporrobles®	Camporrobles	Camporrobles (Valencia)	Plastic 1,500 ml	68.1	64.9 ± 6.2
74	Pascual Nature Los Barrancos®	Los Barrancos	La Ribera de Folgoso (León)	Plastic 1,500 ml	24.6	25.2 ± 2.6
75	Peñaclara®	Riva Los Baños	Torreçilla en Cameros (La Rioja)	Plastic 1,500 ml	139	127.6 ± 11.7
76	Ribes®	Fontaga	Ribes de Freser (Girona)	Plastic 1,500 ml	46.6	37.6 ± 3.8
77	Rocallaura®	Agua de Rocallaura	Vallbona de les Monges (Lleida)	Plastic 1,500 ml	169	178.6 ± 14.8
78	San Andrés II®	San Andrés II	Cuadros (León)	Plastic 8,000 ml	39	35.6 ± 2.8
79	San Antón II®	San Antón II	Firgas (Las Palmas)	Glass 750 ml	16.1	16 ± 1.8
80	San Joaquín®	S. Joaquín de Huelos de Cañedo	Valdunciel (Salamanca)	Glass 750 ml	41.2	39.8 ± 4.1
81	San Narciso®	San Narciso	Caldes de Malavella (Girona)	Glass 1,000 ml	51.4	56.8 ± 6.7
82	Sant Aniol®	Sant Aniol	Sant Aniol de Finestres (Girona)	Glass 1,000 ml	90.7	87.8 ± 8.3
83	Sierra de Cazorla®	Sierra Cazorla	Villanueva del Arzobispo (Jaén)	Plastic 1,500 ml	78.6	69 ± 6.6
84	Sierra de Segura®	Fuente Blanca	Villanueva del Arzobispo (Jaén)	Plastic 1,500 ml	77.7	63.1 ± 6.5
85	Sierra del Aguila®	La Majuela	Cariñena (Zaragoza)	Plastic 5,000 ml	86.3	83.6 ± 8.8
86	Sierra Dúrcal®	Sierra Dúrcal	Dúrcal (Granada)	Glass 500 ml	36.4	35.7 ± 4.0
87	Sierra Fría®	El Chumacero	Valencia de Alcántara (Cáceres)	Plastic 5,000 ml	1.5	1.9 ± 0.7
88	Solán de Cabras®	Fuente de Solán de Cabras	Beteta (Cuenca)	Plastic 1,500 ml	56.9	54.4 ± 5.6
89	Solares®	Fuencaliente de Solares	Solares (Cantabria)	Plastic 1,500 ml	75.3	69.3 ± 5.6
90	Teleno®	Teleno	Palacios de la Valduerna (León)	Plastic 1,500 ml	6	3.6 ± 0.5
91	Valtorre®	Valtorre	Belvis de la Jara (Toledo)	Plastic 1,500 ml	22.9	21.2 ± 2.0
92	Veri I®	Veri	Bisauri (Huesca)	Plastic 5,000 ml	69	65.1 ± 6.1
93	Veri V®	Veri V	Castejón de Sos (Huesca)	Plastic 1,500 ml	31.3	28.1 ± 2.3
94	Vichy Catalán®	Vichy Catalán	Caldes de Malavella (Girona)	Glass 1,000 ml	-	17.5 ± 1.8
95	Viladrau®	Fontalegre	Viladrau (Girona)	Plastic 1,500 ml	27.7	24.4 ± 2.5
96	Vilajuiga®	Vilajuiga	Vilajuiga (Girona)	Glass 1,000 ml	85.3	74.3 ± 7.2
97	Vilas del Turbón®	Vilas del Turbón	Vilas del Turbón - Torrelarribera (Huesca)	Glass 750 ml	50.3	36.1 ± 4.2

Data expressed as means ± SD.

According to information provided by Spanish health authorities, the average calcium concentration of most of the 333 PDW analysed was below 100 mg/L and above 200 mg/L in only four PDW¹⁹.

With regard to NMW, a review of the mineral contents of water commercialized in North America³⁷ found that calcium concentrations were above 100 mg/L in only four of the 28 brands analysed. However, when the same authors analysed the calcium concentrations of 20 waters sold in Europe, they found that the calcium concentration exceeded

100 mg/L in 11 of them. In a descriptive study conducted in Silesia (Poland), the average calcium concentration of 35 NMW analysed was 178.7 ± 107.3 mg/L³⁸. In a study that analysed the chemical composition of 21 types of NMW sold in Saudi Arabia, the authors found that the calcium concentrations analysed in the laboratory ranged from 12 to 90 ppm, although the labels on the bottles indicated that it ranged from 6 to 40 ppm³⁹. Finally, a review of calcium concentration in European NMW found that almost half of them contained over 100 mg/L. Swiss

Table V
Calcium content of 12 imported brands of natural mineral waters

Nº	Brand	Spring	Region	Country	Bottle	Label calcium	Average calcium concentrations (mg/L)
1	Badoit®	Badoit	Saint Galmier (Loire)	France	Glass 750 ml	190	140.4 ± 10.3
2	Evian®	Cachat	Evian (Haute-Savoie)	France	Plastic 1,500 ml	80	68 ± 6.0
3	Jouvence de Wattwiller®	Jouvence	Wattwiller (Haute-Rhin)	France	Plastic 1,330 ml	85	72.3 ± 7.4
4	Pedras Salgadas®	Pedras Salgadas	Vila Pouca de Aguiar (Trás-os-Montes)	Portugal	Glass 250 ml	100	96.5 ± 9.4
5	Perrier®	Perrier	Vergèze (Gard)	France	Glass 750 ml	155	145.1 ± 13.5
6	San Martino®	San Martino	Codrongianos (Sassari)	Italy	Plastic 1,000 ml	167	145.8 ± 9.9
7	San Pellegrino®	San Pellegrino	San Pellegrino Terme (Bergamo)	Italy	Glass 1,000 ml	179	158.4 ± 12.4
8	Saint Geron®	Gallo romaine	Saint Geron (Haute Loire)	France	Glass 750 ml	79.1	82.8 ± 8.6
9	Ty Nant®	Ty Nant Water	Bethania (Llanon)	United Kingdom	Glass 750 ml	22.5	24.3 ± 2.4
10	Vichy-Célestins®	Célestins	Vichy (Allier)	France	Plastic 1,250 ml	103	97.1 ± 9.6
11	Vittel®	Bonne Source	Vittel (Vosges)	France	Plastic 1,500 ml	94	77.5 ± 7.2
12	Volvic®	Clairvic	Volvic (Puy de Dôme)	France	Plastic 1,500 ml	11.5	14 ± 1.6

Data expressed as means ± SD.

NMW had the highest calcium concentrations, which ranged from 436 to 663 mg/L²⁰.

In the present study we also found that the European NMW consumed in Spain, which are mainly bottled in France and Italy, also generally contain higher calcium concentrations than waters obtained from Spanish sources.

The European Food Safety Agency (EFSA), in establishing the recommended dietary allowances of water, assumes that consuming water is fundamental to maintaining good hydration at all stages of life. The Agency also states that roughly 20% of our daily water requirements are provided by foods⁴⁰ (table VI).

Based on this recommended intake of water and on the recommended intake of calcium by age and gender, the percentage of recommended calcium intake provided by water according to its calcium concentration (from 25 to 150 mg/L) has been calculated (tables VIIa and VIIb). These tables show that water

containing a calcium concentration of between 50 and 100 mg/L provides 5.4-12.8% of the RDA for children aged between one and 13, up to 13.6% for adolescents, 5.8-17.6% for adults, 8-16% for expectant mothers, and up to 20.8% for lactating mothers. These data should be taken into account because, according to the bibliography, calcium intake among the Spanish population is insufficient⁷. In 27 of the 108 cities analysed in this study (with a total population of 3,726,377), the calcium concentration of the water was precisely within this 50-100 mg/L range. Moreover, the calcium concentration also ranged from 50 to 100 mg/L in 34 of the 97 Spanish NMW and in six of the 12 imported NMW analysed.

According to our information, waters with a calcium concentration of between 100 and 150 mg/L provide 10-20.4% of RDA in children and adolescents and 17.6-26.4% of RDA in menopausal women. These are stages in which calcium intake is found to be lower⁸⁻⁹.

Table VI
Water adequate intake according the European Food Safety Agency (EFSA)⁴⁰

Age	Adequate intake of water (mL/day)		
	Food*	Water and drinks	Total water
0-6 months	–	–	680
6-12 months	160-200	640-800	800-1,000
1 year	220-240	880-960	1,100-1,200
2-3 years	260	1,040	1,300
4-8 years	320	1,280	1,600
9-13 years (Men)	420	1,680	2,100
9-13 years (Women)	380	1,520	1,900
>14 years (Men)	500	2,000	2,500
>14 years (Women)	400	1,600	2,000
Pregnancy	460	1,840	2,300
Lactating women	540	2,160	2,700

* EFSA states that foods contribute approximately with the 20% of the daily recommendations for water intake; Water and other drinks provide the 80% remaining water daily recommendations.

Table VIII
Adequacy percentage to daily calcium recommendations from water consumption (0-18 years)

	0-6 months	6-12 months	1 year	2-3 years	4-8 years	9-13 years (M)	9-13 years (W)	14-18 years (M)	14-18 years (W)
Calcium RDA (mg/day)	200 (*)	260 (*)	700	700	1,000	1,300	1,300	1,300	1,300
Daily recommended water intake (ml/day)	680	560-800	770-960	910	1,120	1,470	1,330	1,750	1,400
Adequacy percentage to daily calcium recommendations from water consumption									
Average calcium concentrations (mg/L)	25	8.7	5.4-7.6	2.7-3.4	3.2	2.8	2.5	3.4	2.7
	50	17.5	10.8-15.2	5.4-6.8	6.4	5.6	5	6.8	5.4
	100	35	21.6-30.4	10.8-13.4	12.8	11.2	10	13.6	10.8
	150	52.5	32.4-45.6	16.2-20.2	19.2	16.8	15	20.4	16.2

Abbreviations: M, men; W, women. (*) Adequate intake.

Table VIII B
Adequacy percentage to daily calcium recommendations from water consumption (≥ 19 years)

	19-50 years (M)	19-50 years (W)	Pregnancy	Lactating mother	51-70 years (M)	51-70 years (W)	> 70 years (M)	> 70 years (W)
Calcium RDA (mg/day)	1,000	1,000	1,000-1,300	1,000-1,300	1,000	1,200	1,200	1,200
Daily recommended water intake (ml/day)	1,750	1,400	1,610	2,100	1,750	1,400	1,750	1,400
Adequacy percentage to daily calcium recommendations from water consumption								
Average calcium concentrations (mg/L)	25	4.4	4.3	5.2-4	4.4	2.9	3.6	2.9
	50	8.8	8-6	10.4-8	8.8	5.8	7.2	5.8
	100	17.6	16-12	20.8-16	17.6	11.6	14.4	11.6
	150	26.4	24-18	31.2-24	26.4	17.4	11.6	17.4

Abbreviations: M, men; W, women.

Moreover, sufficient intake of calcium during pregnancy has also been found to help prevent eclampsia⁴¹. Consuming water with a calcium concentration of between 100 and 150 mg/L during pregnancy can provide 12-24% of the RDA of calcium. In adults, consuming water with this same calcium concentration (between 100 and 150 mg/L) can provide 11.6-26.4% of the RDA. In women over 51 years of age, whose RDA of calcium is higher (1200 mg/day), consuming water with this calcium concentration can provide 11.6-17.4% of the RDA. These figures are similar for women aged 70. This could be especially important for adults with lactose intolerance or minor digestive problems that require a lower consumption of dairy products-foods which in the west are fundamental to providing calcium, especially for people at risk of osteoporosis⁴².

In the present study, the water of only 6 of the 108 cities had a calcium concentration of over 100 mg/L. The city with the highest concentration was Girona, with an average concentration of 159.7 mg/L. Of the 109 NMW analysed, only 10 had a concentration of over 100 mg/L. The calcium concentrations of five of these ten NMW were between 100 and 150 mg/L. According to the bibliography currently available, waters excessively rich in calcium are not recommended for children still on a milk diet because of the risk of their developing calcium lithiasis. For example, the use of French NMW (Hépar[®]) containing 550 mg/L of calcium to make up starting formulas for babies' bottles was associated with the development of coralliform renal calculus. In this case, the daily calcium intake via water was 1,750 mg/day rather than the recommended daily amount of 210 mg⁴³.

Another aspect that must be taken into account with calcium-rich or hard PDW waters is the softening of the water aimed at preventing the annoying encrustation associated with taps and domestic electrical appliances. Two basic methods of softening water exist: one uses ion exchange resins and the other is reverse osmosis. With ion exchange resins, the calcium is adsorbed and replaced by other ions (especially sodium). The exchange of ions continues as long as there are sufficient ions in the resin to be replaced. Most domestic water softeners use this principle. The Brita[®] filter, for example, removes 89.4% of the calcium contained in the water³⁵. Reverse osmosis is based on the use of a semipermeable membrane that removes 94-98% of the calcium and magnesium. In countries that use desalinated water, the calcium concentration of PDW is therefore below 6 mg/L. In short, domestic filters or reverse osmosis applied to PDW in people's homes almost completely eliminate the calcium content of the water even though the benefits or detriments to the individual of doing so are unknown⁴⁴.

Finally, we should always remember that, from the nutritional point of view, water and milk should continue to be our fundamental beverages and that soda

drinks, because of their low nutritional value, should be consumed only occasionally⁴⁵. Consuming water rather than sugary drinks also helps to prevent overweight and its complications⁴⁶.

In conclusion, a third of the PDW of 108 Spanish cities and 50 of the 109 NMW sold in Spain contain over 50 mg/L of calcium. Given its bioavailability and its use as a healthy means of hydration, drinking water should be taken into account as a complementary dietary source of calcium.

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