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BOTTLED WATERS AS A SOURCE OF MINERALS

Summary: The aim of the study was to determine the content of minerals in bottled waters (natural mineral water and spring water) and compare the results with information declared by the manufacturers. Nineteen types of bottled natural waters available on the local market were examined with flame atomic absorption spectrometry. The results of analyses of bottled waters available on the market showed significant differences in the concentration of the minerals. These differences depended not only on type of the water but was found within one type of product. In addition, the concentrations of the cations under study differed significantly from the values declared by the manufacturers. The biggest discrepancy was detected in the concentration of magnesium ions; in this case, the actual content was incompatible with the declared by the manufacturer one in about 80% of tested samples. These results give also valuable information for consumers, which should be conscious that not every bottled water, it is alike valuable source minerals.

Keywords: bottled water, minerals.

1. Introduction

Bottled water is not only an alternative to tap water, but may also be a good source of minerals [Hoffmann 2007; Latour 2006; Wojtaszek 2006]. The production of bottled natural water constitutes a significant share (37.3%) of beverages market [Rutkowski 2010]. Recently, the market for bottled natural water in Poland has stabilized with a constant upward tendency [Korczyński 2009; Nosecka 2009; Orłowska 2010]. It is alarming that the preferences of young consumers do not include bottled natural water. Also kindergarten children drink coca-cola more frequently than water [Szczepaniak et al. 2002; Żelazna, Kowalczuk 2003; Kowalczuk 2007].

However, the manufacturers more often tend gained customers through lower prices for products of low quality. Due to the large variety of bottled water available on the market and insufficient understanding of this sector, consumers face problems with their choice of bottled water. They mostly choose between still and carbonated water and the content of soluble mineral compounds is important for small group of clients.

From a nutritional point of view it is important which type of water we drink since these products differ in the content and ratio of minerals. Information provided by the manufacturers on the labels should be accurate and reliable. The details on both the labels and in the commercials should not mislead customers. In the case of bottled water, information necessary for identification of the product and details on mineral composition are equally important. Mineral compounds in water are in an ionized, easy absorbable form and therefore are well-absorbed and may replenish mineral deficiencies in the human body [Kochański 2007; Motyka 2000; Kluska 2005; Śmigiel-Papińska et al. 2001; Wojtaszek 2001]. In mineral and spring waters for general consumption (excluding those used in balneology) only some minerals of physiological importance, such as calcium, magnesium, sodium, and potassium, are found in significant quantity. Special health properties are attributed to magnesium (Mg^{+2}) and calcium (Ca^{+2}) cations as well as to the ratio thereof [Kluska 2005]. In these products, the content of calcium ions should be twofold higher than magnesium ions [Hoffmann 2007; Wojtaszek 2001; Kowalski et al. 2011]. The content of this mineral in bottled water may range from 30 to 500 mg/dm^3, whereas the content of magnesium ions is significantly lower, though also varied [Śmigiel-Papińska et al. 2001].

The aim of the study was to determine the content of selected minerals in bottled natural water and compare the results with information declared by the manufacturers.

2. Materials and methods

Nineteen types of bottled water available on local the market were studied, including nine varieties of spring water (described with 1 to 9 codes) and ten varieties of natural mineral water (described with 10 to 19 codes). Every sample was analysed in three repetitions. Due to the influence of carbon dioxide on the accuracy of measurements, natural mineral water was decarbonized prior to analysis. Water was poured from bottles into a dry, clean container and then left for 24 hours. Next, a sample of each water was appropriately diluted with deionized water so as the concentration of measured element would remain within the range of standards used in the analyses. Moreover, in order to eliminate the impact of phosphorus on the measurement of calcium, a 10% water solution of lanthanum chloride was added to each dilution in an amount ensuring a final 1% concentration of $LaCl_3$.

Determination of calcium and magnesium ions was performed with flame atomic absorption spectrometry, AA spectrometer Unicam 939 Solar, England, equipped with an Optimus data station, background correction (deuterium discharge lamp) and proper cathode lamps. The concentrations of sodium and potassium were determined with a flame atomic emission spectrometry in an acetylene-air flam, AA spectrometer Pye Unicam SP 2900, England, operating in emission system [Whitside, Miner 1984].

The measurements were carried out with the parameters presented in the table below (tab. 1).

Table 1. Parameters of sign in studied bottled waters the content of individual mineral relationships

Chemical element	Ca	Mg	Na	K
Mode of work	Absorbance	Absorbance	Emission	Emission
Technika	Flame	Flame	Flame	Flame
Type of flame	Air-C2H2	Air-C2H2	Air-C2H2	Air-C2H2
Fuel flow	1,0 l/min	1,0 l/min	1,0 l/min	1,0 l/min
Length of wave	422,7 nm	285,2 nm	589,0 nm	766,5 nm
Slot	100% height 0.5	100% height 0.5	100% height 0.5	100% height 0.5
Current of lamp	80%	80%	00%	00%
The time of measurement/the stabilization of flame	4,0 seconds	4,0 seconds	4,0 seconds	4,0 seconds
Individual of concentration	mg/l	mg/l	mg/l	mg/l
Standard 1	0,500	0,050	1,000	5,000
Standard 2	1,000	0,100	2,000	10,000
Standard 3	2,000	0,200	4,000	20,000

Statistical processing was subjected got results defining standard deviations applying programme STATISTICA.

3. Results and discussion

The analysis of tested bottled waters found significant differences in the content of minerals under the study. This large variation in mineral composition depends on the origin of water as a raw material. Water extracted in the same region, but from different sources, may differ in composition [Hoffmann 2007; Latour 2006].

The analysis of label information on the bottles of water revealed that, in one case, the details on mineral composition were not provided, which made it impossible to compare it with the results of the measurements. It should be noted that it is not obligatory to provide such information in the case of natural spring water. However, if such information steps out, they should be credible [Regulation of the Minister of Health of 31st March 2011].

The concentration of calcium ions in the tested products (tab. 2) ranged from about 36 to about 98 mg/l in spring water (samples 1-9) and from about 80 to about 334 mg/l in mineral water (samples 10-19). The comparison of these results with the declared by the manufacturers values showed some differences. However, the concentration of mineral compounds in bottled water may slightly vary and a maximum 20% difference between the actual and declared concentration of compounds is accepted. Higher (above 20%) differences between measured and declared concentra-

tions were detected in two products in which the declared content of calcium ions was either higher or significantly lower than that declared on the label (samples 9 and 11).

Table 2. Determined and declared by the manufacturers content of calcium in bottled natural waters

No	Determined content [mg/l]	Declared content [mg/l]	Percentage difference between determined and declared contents [%]
1	37.90 ± 0.21	42.62	11.43
2	56.90 ± 0.31	55.30	2.98
3	79.81 ± 0.24	69.14	17.17
4	36.58 ± 0.21	lack of information	not counted
5	75.20 ± 0.32	78.00	3.59
6	95.70 ± 0.35	98.99	3.32
7	45.50 ± 0.20	47.09	3.38
8	97.60 ± 0.38	112.20	13.01
9	53.17 ± 0.21	43.69	21.70
10	333.98 ± 0.41	324.60	2.89
11	65.20 ± 0.23	97.80	33.33
12	304.00 ± 0.33	318.70	4.61
13	198.97 ± 0.20	180.90	9.99
14	299.67 ± 0.31	258.20	16.06
15	79.70 ± 0.14	74.15	7.49
16	114.60 ± 0.19	110.20	4.00
17	105.10 ± 0.23	102.20	2.84
18	157.15± 0.21	161.10	2.45
19	133.43 ± 0.21	128.26	4.03

An analysis of magnesium ions revealed major differences in the concentrations of magnesium in the tested products: from several to over one hundred milligrams per litre (tab. 3). In the majority of tested products, these values were significantly lower than the concentration declared by the manufacturers. In the group of natural spring water (samples 1-9), the actual concentration of magnesium ions was over 50% lower than given on the label, whereas in the group of mineral water (samples 10-19), the discrepancy was found in 70% of tested products with the differences between measured and declared concentration ranging respectively from 30 to over 60%.

Table 3. Determined and declared by the manufacturers content of magnesium in bottled natural waters

No	Determined content [mg/l]	Declared content [mg/l]	Percentage difference between determined and declared contents [%]
1	2.67 ± 0.10	5.52	51.63
2	11.00 ± 0.22	27.40	59.85
3	5.06± 0.10	12.76	60.34
4	2.75± 0.11	lack of information	not counted
5	4.82 ± 0.20	12.00	59.83
6	7.80 ± 0.21	20.67	62.26
7	1.09 ± 0.12	6.08	82.07
8	8.80 ± 0.21	24.3	63.79
9	1.57 ± 0.11	5.05	69.91
10	44.66 ± 0.31	53.82	17.13
11	9.46± 0.20	13.13	27.95
12	33.40± 0.13	32.30	3.41
13	102.67± 0.20	142.70	28.05
14	31.00± 0.19	51.15	39.39
15	8.03± 0.21	13.37	39.94
16	16.71 ± 0.27	23.10	27.66
17	12.67 ± 0.30	16.00	20.81
18	13.40± 0.10	15.31	12.48
19	14.57± 0.10	21.26	31.47

A comparison of magnesium and calcium cations contents showed that very often the concentration of magnesium ions was several times lower than the content of calcium ions, which is unfavourable from a nutritional point of view (tab. 3, 4), where special health properties are attributed to magnesium and calcium cations as well as to the ratio thereof [Kluska 2005].

The tested bottled water also showed differences in the content of sodium ions (tab. 4). A higher concentration of sodium cations was detected in the majority of natural mineral waters than in spring ones. However, the discrepancy in the concentration of this mineral compound was found in half of these products. The actual concentration of sodium ions often differed by several dozen per cent from the values declared by the manufacturer. These concentrations were lower than declared in some products and higher than declared in others (samples 11, 12, 13, 15, 18). In the analysed samples of spring water, the level of mineralization was lower than in mineral water and a discrepancy in the concentration of sodium cations was detected in two products in which it was below the declared value.

Table 4. Determined and declared by the manufacturers content of sodium in bottled natural waters

No	Determined content [mg/l]	Declared content [mg/l]	Percentage difference between determined and declared contents [%]
1	7.88± 0.21	9.73	19.01
2	1.39± 0.19	1.40	0.71
3	4.92± 0.20	5.00	1.60
4	12.39± 0.28	Lack of information	Not counted
5	5.17± 0.19	6.40	19.22
6	10.29± 0.29	11.87	13.31
7	2.11± 0.19	2.81	24.91
8	12.86± 0.19	13.00	1.08
9	3.87± 0.19	9.70	60.1
10	111.22± 0.28	112.90	1.49
11	8.20± 0.20	4.49	82.63
12	16.46± 0.19	11.60	41.90
13	87± 0.27	63.00	38.40
14	14.32± 0.17	14.10	1.56
15	5.57± 0.18	8.12	31.40
16	8.86± 0.10	11.00	19.45
17	11.59± 0.19	11.25	3.02
18	39.28 ± 0.17	56.79	30.83
19	9.89± 0.19	10.00	1.1

In the majority of tested products, the concentration of potassium ions was approximately several milligrams per litre and only in one product (in one type of natural mineral water) was it much higher, reaching about 50 mg/l (tab. 5).

Table 5. Determined and declared by the manufacturers content of potassium in bottled natural waters

No	Determined content [mg/l]	Declared content [mg/l]	Percentage difference between determined and declared contents [%]
1	2.182 ± 0.10	Lack of information	Not counted
2	1.11 ± 0.11	0.70	58.14
3	1.15 ± 0.20	0.75	54.46
4	2.90 ± 0.29	Lack of information	Not counted
5	1.76 ± 0.18	1.70	3.35
6	2.64± 0.18	Lack of information	Not counted

Table 5. Determined and declared by the manufacturers content of potassium in bottled natural waters (*continued*)

No	Determined content [mg/l]	Declared content [mg/l]	Percentage difference between determined and declared contents [%]
7	1.37 ± 0.13	1.04	31.83
8	5.54 ± 0.19	4. 00	38.38
9	0.67 ± 0.11	1.60	58.06
10	51.18 ± 0.29	47.31	8.18
11	1.25 ± 0.11	2.31	45.85
12	4.37 ± 0.17	2.89	51.21
13	8.28 ± 0.28	7.50	10.40
14	4.06 ± 0.17	3.94	3.04
15	1.56± 0.10	1.35	15.56
16	3.74 ± 0.17	2.80	33.57
17	3.43 ± 0.18	2.34	46.58
18	4.68 ± 0.17	4.97	5.84
19	4.68 ± 0.16	2.50	87.20

These results show that in a half of the tested products the actual concentration of potassium cations is incompatible with the content declared by the manufacturers and exceeds the accepted 20% difference. The majority of discrepancies resulted from the fact that the concentration of this element in the tested products was several dozen higher than the value declared by the manufacturer. In three products, i.e. spring water, the lack of this information on the label prevented the verification of the compatibility of potassium ion concentrations.

4. Conclusions

The results of analyses of bottled natural water available on the Olsztyn market showed significant differences in the concentration of such elements as calcium, magnesium, sodium and potassium. These differences were observed not only in different types of natural bottled water, but even within one type of products. In addition, the concentrations of the cations differed significantly from the values declared by *the* manufacturers. The biggest discrepancy was detected in the concentration of magnesium ions; in this case, the actual content was incompatible with the content declared by the manufacturer in app. 80% of tested samples. The results also revealed differences in the concentration of sodium and potassium ions in relation to the content given on the label. The actual concentration of calcium ions was incompatible with producer's declaration in only one case. The discrepancies in the min-

eral composition may have resulted from changes in the physical and chemical composition of natural sources or unreliable information given by the manufacturers. More frequent sanitary control analysis should help to eliminate these discrepancies. These results give also valuable information for consumers, which should be conscious that not every bottled water, it is alike valuable source minerals.

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WODY BUTELKOWANE JAKO ŹRÓDŁO SKŁADNIKÓW MINERALNYCH

Streszczenie: Celem niniejszej pracy była ocena zawartości wybranych związków mineralnych w wodach butelkowanych (naturalnych wodach mineralnych i wodach źródlanych) oraz porównanie uzyskanych wyników z wartościami deklarowanymi przez producentów. Ocenie poddano dziewiętnaście wód butelkowanych dostępnych na rynku. W badanych produktach dokonano oceny zawartości takich makroelementów, jak: wapń, magnez, sód i potas. Zawartość makroelementów w postaci jonów w badanych próbkach wód butelkowanych oznaczono techniką płomieniowej spektrometrii absorpcji atomowej.
Uzyskane wyniki badań wód butelkowanych występujących na rynku wskazują na duże zróżnicowanie w zawartości takich składników mineralnych, jak: wapń, magnez, sód, potas. Zróżnicowanie to stwierdzono nie tylko pośród różnych rodzajów naturalnych wód butelkowanych, lecz również w obrębie jednego rodzaju produktów. Ponadto oznaczone zawartości poszczególnych kationów znacznie się różnią od tych deklarowanych przez producenta. Największe niezgodności stwierdzono w przypadku zawartości jonów magnezu, gdzie w około 80% badanych próbek rzeczywista zawartość tych jonów była niezgodna z deklarowaną przez producenta. Uzyskane wyniki badań dają także cenne informacje konsumentom, którzy powinni być świadomi, że nie każda woda butelkowana jest jednakowo cennym źródłem oznaczanych związków mineralnych.

Słowa kluczowe: wody butelkowane, związki mineralne.