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Comparison between real and label content of different bottled water brands from Saudi Arabia and other countries.

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Abstract:

Bottled water is consumed in many countries of the world to access safe and clean water. Good drinking-water quality of bottled water has high importance for human health, and standards for drinking-water quality have been defined by World Health Organization (WHO) and GCC Standardization Organization (GSO). Deviations from these standards may cause mild to severe health constraints. For consumers, the water composition is indicated on a label attached to the water bottle. Reports about wrong label information were the motivation for a large study of the real content of 20 different bottled water brands from Saudi Arabia in comparison with 19 brands from different countries in Asia, Oceania, Africa, and Europe. The pH, total dissolved salt (TDS) concentration, and concentrations of nine cations and anions are measured to determine for all Saudi and international brands that the water content is conform with the standards for drinking-water quality, confirming that bottled water from all tested brands is safe for consumption. Furthermore, this measured real content agrees for most tested brands with the water content indicated on the bottle labels, proving the labels' reliability. Statistical analysis also reveals that the drinking-water quality of the Saudi brands is comparable to that of the international brands. Considering the increase in consumption of bottled water, especially in geographic areas where no tap water of drinking-water quality is available, quality control of bottled water becomes essential, aiming for correct information on the bottle label to reliably inform consumers and ensure human health.

Keywords: Label Content, Bottled Water Brands, Saudi Arabia

Introduction

Access to drinking water is a basic human need, and bottled water has become the major source for safe and pure drinking water in many countries of the world. Drinking-water quality is determined by the water's chemical composition, such as the content of macro- and micronutrients and the amount of total dissolved salts as well as related physical properties (e.g., pH value, electrical conductivity). Furthermore, possible contamination with toxic or radioactive chemicals as well as microorganisms has a negative impact on the water quality Standards for drinking-water quality have been defined by organizations like the World Health Organization (WHO) and the GCC Standardization Organization (GSO) by indicating reference values for different water components (WHO, 2006; GSO Technical Committee, 2008) [1-4]. Consumption of water with one or more components exceeding these reference values may present a severe risk to human health. For example, a low calcium concentration increases the coronary disease risk, while a high concentration will lead to a bad water taste [5]. Moreover, high fluoride concentrations present a health risk for children, and boron is a known carcinogen [2]. Therefore, to preserve human health, a strict control of the bottled water composition is needed. To judge on water quality and the mineral content of bottled water, consumers must rely on the information indicated on the attached label. This is provided by the bottled water company and is based on the company's water analyses, stating volume, pH, and analytical composition regarding macronutrients (Ca, K, Mg, and Na) and micronutrients-trace element (Co, Cr, Cu, Fe, Mo, Se, and Zn) contents (GSO Technical Committee, 2019). As consumers' only source of information about the bottled water composition, the label's correctness must be ensured, and deviations between label and real content may have a direct impact on human health if the standards for drinking-water quality are not obeyed. Therefore, reports about labels indicating inaccurate elemental concentrations of bottled waters are alarming. A previous study by Moazeni showed that Iranian bottled drinking waters often present higher or lower values of some parameters with respect to the labelled amounts [6].

In Saudi Arabia, water is a highly valuable resource, and the Saudi production of desalinated water is the largest in the world, covering 70 % of the country's demand [1]. Different types of water are consumed, including tap and bottled water, with an increased consumption of bottled water in the last decades [5]. The main water sources for bottled water are sea and underground waters. Bottled drinking water

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must be treated by adding natural minerals to meet the standards for drinking-water quality, while bottled natural mineral water can be directly filled from natural underground sources that provide water in drinking-water quality (GSO Technical Committee, 2019). Hamad analyzed six bottled water brands and reported that some components were in agreement with the GSO standards, but some elements were below the references limits [7]. The authors proposed that continuous water assessment should assure the water quality and avoid health hazard. Another study compared the real content of different elements with the content indicated on the label on the bottles of different bottled water brands in Saudi Arabia. The study revealed fluoride and bromate concentrations above the established limits as well as further significant differences between label and real content [2].

The high importance of providing bottled water with drinking-water quality and the necessity of reliable labels attached to the water bottles in combination with alarming studies about deviations of real content from drinking-water quality as well as label content were our motivation to evaluate the real content of water from various Saudi and international bottled water brands. We analyzed bottled water from 20 Saudi brands as well as 19 international brands from 14 countries worldwide and compared their real contents to established drinking-water standards as well as the label content and tried to draw conclusions about country-specific differences between Saudi- and international brands. Our study focuses on measurements of pH value, total dissolved salt (TDS) concentration, as well as the concentrations of five cations (Na, K, Ca, Mg, Fe) and four anions (Cl, F, nitrate, sulfate) as the basis for our comparison regarding drinking-water standards, label correctness, as well as country-specific differences.

Materials and Methods

Materials

Unless otherwise mentioned, materials were purchased from Merck (Germany), and reagents were of the highest available purity.

Water samples

Samples were taken from bottled water of 39 different brands and 15 different countries. From Saudi Arabia, bottled water of the following 20 brands was analyzed (in parentheses: bottle volume (mL)): Arwa (500), Afnan (600), Aquafina (600), Azbah (600), Bambini (330), Berain (600), DEEM (600), Fayha (600), Hana (600), Hijra (600), Manahl (600), Manao (250), Mawared (600), Naba (600), Nova (600), Nuran (330), Panda (600), Safa (600), Taiba (600), and Tania (600). Furthermore, bottled water of 19 brands from the following 14 countries was analyzed (in parentheses: brand, bottle volume (mL)): Croatia (Elite, 500), Egypt (Dasani, 600), Fiji Islands (Fiji), Finland (Nord Water, 500), France (Evian, 500/1000; Evian Live, 500; Vittel, 750; Volvic, 500), Indonesia (AQUA, 600), Jordan (Al tharawat, 600), Lebanon (Tannourine, 500), Morocco (Olmas, 500), Scotland (Highland, 500), Sudan (Safia, 600), Syria (BouKein, 500), Turkey (Hamidiya, 500; Pinarim, 330), United Arab Emirates (Alain, 500; Jeema, 600). Water bottles of Saudi brands were obtained from stores in Saudi Arabia, while all bottles of international brands were bought from stores in the listed countries. Samples were collected according to Saudi Arabia Standard (407/1989) and Gulf Standard (111/1989).

Laboratory analysis

The pH measurements were performed using a pH meter (HANNA pH 211, Hanna Instruments Italia Srl, Villafranca Padovana, Italy), and total dissolved salt (TDS) concentrations were measured using a TDS meter (HACH Company, Loveland, CO, USA). Concentrations of cations like sodium (Na^+), potassium (K^+), magnesium (Mg^{2+}), calcium (Ca^{2+}), and iron (Fe) were measured using the instrument DR/4000 Hach (HACH Company, Loveland, CO, USA) and the atomic absorption spectrophotometer (AAS) Varian Spectr AA 110 (Varian, Palo Alto, CA, USA). Concentrations of anions, such as chloride (Cl^-), fluoride (F^-), sulfate (SO_4^{2-}), and nitrate (NO_3^-), were measured by ion chromatography (Metrohm, Riverview, FL, USA). All measured values are referred to as the "real content", and concentrations are express in ppm.

Results

Water samples of 20 bottled water brands from Saudi Arabia were analyzed and compared with water samples of 19 international bottled water brands from 14 different countries worldwide, as detailed in the Materials and Methods section. For all samples, pH value, TDS content, as well as anion (Cl^-, F^-, SO_4^{2-}, NO_3^-) and cation (Na^+, K^+, Mg^{2+}, Ca^{2+}, Fe) concentrations were measured, and the results are presented in Tables A1 and A2. Furthermore, Tables A1 and A2 lists the corresponding values for these parameters indicated on the bottle labels (referred to as "label content").

Conformity with water quality standards

Tables A1 and A2 reveal that mean and minimum TDS levels of most tested bottle water samples were within the limits established by the GSO (GCC Standardization Committee, 2008). However, one brand from France exceeded the 600-ppm reference limit by exhibiting a real TDS value of 1084 ppm, while only 466 ppm were declared on the label. Similarly, the chemical analysis of one of the Turkish water samples revealed that the real pH value was above the 8.0 reference limit set by the GSO, while the label indicated a value within the GSO reference range.

The same French brand that exceeded the TDS value limit was also the only brand that exceeded the maximum GSO sulfate reference value of 250 ppm with a real value of 400 ppm. Furthermore, the real sulfate content was lower compared with its label content of 675 ppm. No health-based guidelines have been proposed by WHO (2008) or GSO (GCC Standardization Committee, 2008) for the chloride content in bottled water, although excessive chloride over 250 ppm has been associated with salty taste. Almost all samples obeyed the standards of the KSA (2003), which indicate that the chloride content should be below 150 ppm. Only one sample from Morocco exhibited a higher chloride concentration of 278 ppm. For the fluoride content, the WHO has defined a limit of <1.5 ppm because higher fluoride concentrations are harmful for children. Only two brands, one from Saudi Arabia and a second one from Jordan, showed measured values that exceeded the limit but were lower than 2 ppm, while the fluoride label content was within the reference range. Furthermore, the nitrate content of all water samples was in agreement with the GSO guidelines. However, the label content was higher than the real content but always below the 50-ppm limit.

WHO and GSO do not define a reference range for the sodium content in bottled water? Nonetheless, KSA guidelines indicated a 100-ppm limit, which was respected in all tested samples, while the Morocco brand declared a sodium content on the bottled label that was 3-fold higher than the established limit. However, the measured value was only 76 ppm, thus lower than the limit. For magnesium and iron, the values measured for all brands were within the GSO reference ranges.

Comparison Saudi Arabia vs. international brands

Based on Tables A1 and A2, the mean values for pH value, TDS concentration, as well as cation (Ca, Mg, K, Na, Fe) and anion (nitrate, sulfate, Cl, F) concentrations were calculated for bottled water samples from the 20 Saudi brands and the 19 international brands, as depicted in Fig. 1. One-way ANOVA comparisons revealed that the mean real TDS content of the samples from international brands was significantly higher than that of the samples from Saudi brands ($p<0.0001$). In contrast, no significant difference was detected between Saudi and international brands for the samples' pH values as well as cation and anion concentrations.

Comparison real vs. label content

In order to compare the real content of all measured parameters with the respective label content (see Tables A1 and A2), ANOVA comparisons of the mean values of bottled water from the Saudi brands as well as from the international brands were performed, as presented in Fig. 2a,b, respectively. These comparisons revealed that for both Saudi and international brands, almost all measured parameters (Fig. 2a) were close to those declared on the labels ($p > 0.05$). However, the difference between real and label content was not statistically significant for the international brands (Fig. 2b).

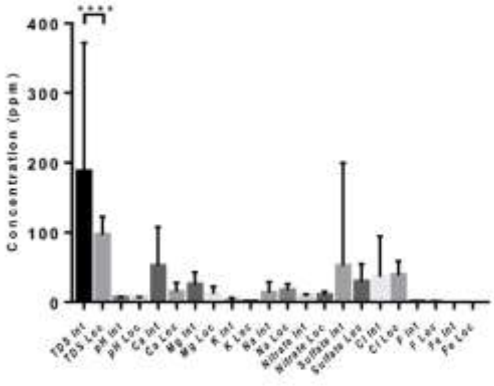

Figure 1: Comparison between the real contents in bottled water from Saudi Arabia (loc) and international brands (int) based on the mean values of total dissolved salt (TDS) concentration (in ppm), pH value (unitless), as well as anion and cation concentrations (in ppm).

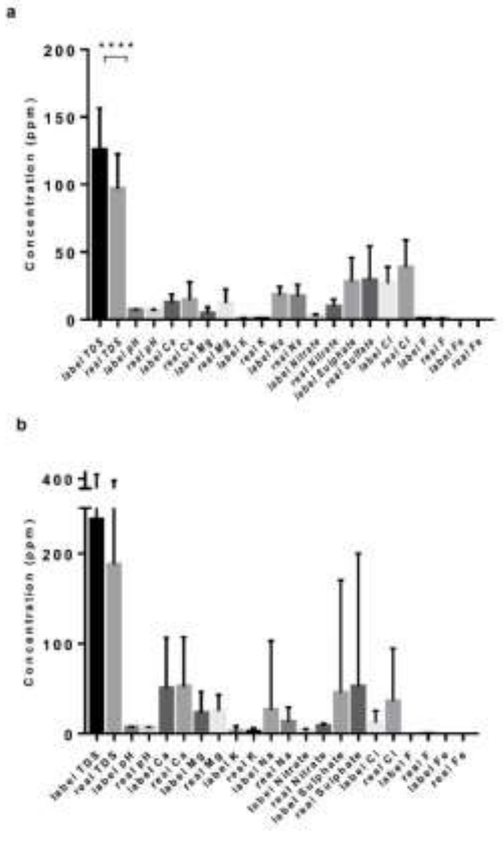

Figure 2: ANOVA comparison between label and real content in bottled water samples from Saudi brands (a) and international brands (b).

Furthermore, the mean real/label content differences were compared between bottled water samples from Saudi and international brands, as shown in Fig. 3. The results revealed no statistically significant difference for any of the measured parameters ($p>0.05$).

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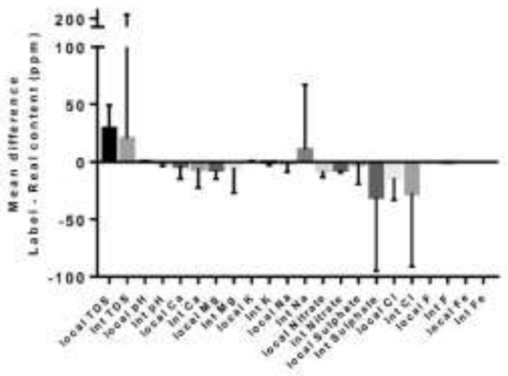

Figure 3: Comparison of the mean difference between label and real content (real content subtracted from label content) in Saudi brands vs. international brands.

Bacteriological analysis

In addition to the analysis of salt content and pH value presented above, a bacteriological analysis for Escherichia coli and coliform bacteria was performed, as also a bacterial contamination of bottled water presents a possible hazard for human health. However, our analysis showed that all 39 samples were negative for Escherichia coli and coliform bacteria, indicating that the analyzed bottled waters were suitable for human consumption and do not present any risk for human health.

Discussion

In this study, we compared label and real contents of bottled water of 20 brands from Saudi Arabia and 19 international brands from different countries in Asia, Oceania, Africa, and Europe. To the best of our knowledge, this is the first study that compares the quality of Saudi bottled water brands with respect to international brands. This comparison suggested that the quality of Saudi bottled water is comparable to that of the international brands. Furthermore, our analysis showed that the values indicated on the bottle labels were accurate or overestimated in some cases, suggesting that the analyzed bottled waters are safe and respect the guidelines established either by GSO, WHO, or KSA.

Some studies demonstrated considerable differences between real and label contents, and, in some cases, the real content did not agree with the quality standards. Alfadul and Khan found discrepancies among real and label content in water samples for both Saudi brands and international brands [8]. A previous study on bottled water samples from Ethiopia showed that some parameters like pH and TDS were above the reference limits, while other parameters were very low [9]. Al-Omram (2013) also evaluated brands available in Riyadh city (Saudi Arabia) and reported that 18 % of these samples exceeded the reference limits, while many samples showed inaccurate values on the bottle labels. Stanič revealed that the storage conditions of the bottles may also alter the water composition [10]. High temperatures might stimulate crystal formation and precipitation depending on the composition of the water. The authors indicated that the presence of Mg, sulfate, Na, and K, among other components, might reduce this effect. The storage conditions might, at least partially, explain the differences found between real and label contents in some studies.

For the pH value, no guidelines have been proposed by WHO or GSO, as the pH does not directly affect human health in a certain range, although it should be preferably below 8.0 (WHO, 2008). However, the pH value of one sample of a Turkish brand exceeded this value by 0.2. As this sample is natural spring water, this higher pH value may result from the presence of potential contaminants. Although not directly affecting human heath, such deviations are an indicator for the quality of the water, and alkalinity may cause pipe and appliances damage (WHO, 2008), which may lead to water contamination. On the other hand, acidic pH values lower than 5.5 may favor caries formation [11]. A previous study reported low pH values for bottled water of some popular brands, potentially causing dental erosion and tooth decay [11]. In his study, Wright proposed that patients should become aware of the pH of the water they consume in order to avoid dental problems and gave the advice to drink alkaline water to protect from tooth decay [11].

Our study showed that one natural mineral water sample from France exhibited higher levels of TDS and sulfates than proposed by the GSO. However, TDS French guidelines recommend different mineral water contents than WHO and GSO [10]. Although there are no reference limits for TDS, French guidelines suggest a mineral content classification between very low, low, and rich for fixed residues below 50 mg L-1, below 500 mg L-1, and above 1500 mg L-1 at 180°C, respectively. Fixed residues and TDS are both measures of the salt content, but fixed residues are calculated by weighting the sample before and after heating at 180 °C, while the TDS content is obtained by electrical conductivity measurements. One explication is that French guidelines allow a greater TDS content. Furthermore, the TDS varies according to geographic regions, suggesting that samples taken from natural spring waters may present a higher characteristic TDS value, which is not necessarily harmful according to the [10]. According to our knowledge, no data are available about health effects of TDS, but high levels might affect consumers' acceptability (WHO, 2008). In contrast, TDS was found to be the only parameter that was significantly lower in bottled water samples from Saudi brands with respect to international brands. Even more, the real content of TDS in Saudi brand samples was even lower than the label content. These differences may be also explained by differences in the geographic regions of water origin. Furthermore, the bottled water samples analyzed in this study resulted from both purification of natural sources and natural mineral waters. It is expected that natural mineral waters present a higher content of TDS, which may contribute to the high TDS values measured for the French brand discussed above.

The higher sulfate concentration in one French bottled water sample may be explained by French guidelines, which value high sulfate concentrations of more than 200 ppm by classifying such water as "sulfate water". It has been reported that sulfate has beneficial effects on human health and is considered a macronutrient [12]. However, sulfate can affect the water taste and even cause a laxative effect, but the taste is only slightly affected if the sulfate level is below 250 ppm (WHO, 2008) [13].

Nitrate is a potential contaminant of bottled water, and groundwater can become contaminated by different sources like sanitation, agricultural activities, and waste disposal, which decline the water quality [9]. Excessive nitrate content can result in the development of methemoglobinemia in children [4]. Nitrate assessment is used as a measure of the water quality, and 50 ppm was established as a reference limit (WHO, 2008). Some countries from Sub-Saharan Africa, India, and China have been reported to exhibit higher values of nitrate in their waters [9]. Alimohammadi et al. evaluated the content of 71 bottled water brands from Iran and found that some samples exceeded the reference limit [4]. The authors indicated that such results should lead to take measures to reduce the nitrate content in bottled water. In contrast, our study showed that the nitrate content of all analyzed water samples was below the reference limit established by GSO and WHO, indicating that no nitrate contamination affects the water quality of any analyzed bottled water sample. This supports the fact that the consumption of bottled water from all brands tested in this study is safe. Particularly, Sudan, a Sub-Saharan African country, presented a bottled water of good drinking-water quality.

High sodium content is related with cardiovascular diseases, and particularly hypertension, and may affect the water taste depending on the anion. However, no specific limit for sodium has been established by WHO and GSO, but the WHO proposed a taste threshold of 200 ppm, without any related health guide, while the KSA guidelines suggest a limit of 100 pm. Regarding its nutritional properties, sodium is declared as a macronutrient, along with potassium (which presents no reference limit suggestion) and calcium [12]. However, considering the relationship with cardiovascular diseases and hypertension, a strict control or reference limit for the sodium content is advisable. The assessment of the Na content in bottled water samples from France, Italy, Czech Republic, and Lithuania showed that medially to highly mineralized waters presented various concentrations of Na, and that the intake of 1 L of such water could lead to an excessive intake of Na [11]. Our results showed only for the Morocco water brand a high sodium content of 76 ppm, which agreed with the KSA reference limit. Instead of labeling too-high sodium content, the GSO proposed to mark sodium contents below 20 ppm by indicating the phrase "low sodium content" on the label.

Fluoride has a relevant function in bone health and prevention of dental caries (WHO, 2008). However, excess of fluoride has been related to diseases like dental and skeletal fluorosis where decoloration or staining occurs generally in children below 4 years old [12-14], and a maximum value of 1.5 ppm has been proposed by the WHO (2008). Some bottled water brands may have added fluoride, and fluoride addition must be declared on the label according to the GSO. However, to our knowledge, no fluoride is added to any of the here tested brands. It has been shown that a 2-fold increase of fluoride in water does not affect human health regarding the risks for cancer, cardiovascular events, or asthma; however, it causes dental fluorosis in children ages 7–13 years old [15]. In fact, fluorosis is the only confirmed negative effect on health although harmful effects on bones, kidneys, muscles, and nerves have been suggested [8] [16]. Given the few scientific reports about fluoride toxicity, the measured content of fluoride in the mentioned brands is supposed to be not harmful. However, previous reports indicate that bottled water brands sometimes inaccurately report their fluoride content [17-21]. A study by Moslemi revealed that the mean fluoride level of the analyzed bottled water was lower than the accepted standard [21]. The authors emphasized the relevance of accurately measuring fluoride levels, not only to guarantee safety but also the access to fluoridated water and its beneficial effects. Thus, an accurate label for the fluoride content would be important to assure safe consumption, especially among children. Our study showed for most tested brands fluoride levels within the 1.5 ppm limit. Only the measured fluoride level of two brands from Saudi Arabia and Jordan exhibited values higher than the 1.5 ppm limit but still below 2 ppm. The real content deviated from the label content, which indicated fluoride levels within the reference range. This difference between label and measured fluoride concentration may result from different analytical techniques applied in our study (ion selective electrode) and those used by the water company [21].

Investigating the content of bottled water is essential, not only regarding its salt composition, physical properties, and microorganisms but also the presence of toxic chemicals (e.g., Al, As, Cd, Hg, Pb, Th, U). Some toxic substances have been thoroughly studied, and these substances can be effectively eliminated by water treatment. Nevertheless, changes in environment and human activity can affect quality and safety of bottled water. A recent study proposed that the water quality has been decreasing in drinking-water sources since 1999 [7, 22-25]. Evaluation of the water sources revealed that parameters like Kjealdahl nitrogen, alkalinity, conductivity, and pH have increased, resulting in a lower water quality. Changes in the composition of the water sources could cause new challenges in water treatment. Furthermore, the fact that water is filled and stored in plastic bottles has raised concerns about the potential risk of phthalate traces in bottled water, especially considering the lack of analysis of their content [19]. More than 300 brands from 20 different countries have been analyzed regarding their phthalate content, and Saudi Arabia ranked among the top 5 countries with higher mean content of di-2-(ethylhexyl) phthalate [19,26-29]. Considering the human daily intake, exposure to phthalates contained in bottled water is not expected to present a serious concern for public health. However, estrogen-disrupting activity of phthalates has been observed in some countries [19], suggesting the need for more efforts to assure water safety regarding the phthalate content.

Conclusion

We analyzed samples of 20 bottled water brands from Saudi Arabia as well as 19 brands from different countries worldwide regarding pH value, TDS content, as well as anion- and cation concentrations. Our results showed that all samples were in agreement with either Saudi (GSO) or international guidelines (WHO), indicating that all brands provide water of drinking-water quality that is safe for consumption. The average quality of bottled water from Saudi brands was found to be comparable to that of the tested international brands. Furthermore, the measured real content agreed with the label content for all Saudi as well as the majority of international brands, proving that the attached labels are a reliable source of information about bottled water composition and characteristics. Considering that bottled water intake is increasing, especially in geographic areas where tap water is not available to human consumption, quality control of bottled water becomes important to ensure drinking-water quality. In this regard, our results are of utmost importance for Saudi bottled water consumers, as they clearly prove that Saudi bottled water is safe, obeys international standards, and is reliably labeled. In future studies, variations among batches of one brand remain to be investigated to detect possible inaccuracies among batches as well as batches exceeding reference values or with deviations between real and label content. Furthermore, careful studies about potentially harmful effects of different water components on human health remain to be performed in clinical research to ensure safe long-term exposure.

Appendix

Table A1. Total dissolved salt (TDS) concentration, pH value, and anion- and cation concentrations of water samples of 20 Saudi as well as corresponding descriptive statistics. For every concentration or pH value, the label content is indicated below the corresponding real content in parentheses. Units: TDS, Ca, Mg, K, Na, NO_3, SO_4, Cl, F, Fe in ppm; pH: unitless. SD = standard deviation.‡ GSO guidelines (GSO, 2008);[a] KSA guidelines [18].

Real (label) content of Saudi brands											
Brand No.	TDS	pH	Ca	Mg	K	Na	NO3	SO4	Cl	F	Fe
1	84	6.7	0	40.3	0.5	3.3	5.9	110	5.9	1.1	0.01
	(121)	(6.8)	(1.0>)	(21.1)	(1>)	(3)	(1>)	(74.5)	(1.0>)	(1.2–0.8)	
2	104	6.5	15.8	14.7	1.2	21.7	18.1	34	41.5	1.6	0.02
	(115)	(7.1)	(10)	(2.3)	(1)	(29)	(3.4)	(28)	(35)	(1)	
3	96	6.57	4.8	28	1.2	12.4	6.3	67	31.8	0.98	0.02
	(110)	(7)	(<5)	(13)	(1)	(16)	(<0.1)	(51)	(27.5)	(1)	(0.01)
4	92	6.6	3.5	6.8	0.6	22.1	9.2	14	25.8	0.81	0.05
	(127)	(7.2)	(8)	(3)	(1)	(22)	(3)	(32)	(40)	(1)	
5	87	6.64	12.6	32.6	0.4	16.5	9.9	32	63.5	0.81	0.02
	(120)	(7.2)	(14.4)	(3)	(1.5)	(12.3)	(2)	(28)	(17.5)	(0.9)	(0,0)
6	67	6.6	16	2.9	0.1	11.7	5.3	9	23.9	0.88	0.02
	(135)	(7.2)	(20)	(2.5)	(0.25)	(16)	(1)	(9)	(33)	(1)	(0)
7	76	7.76	20	5.9	0.1	9.8	7.2	11	41.7	1.29	0.05
	(100)	(7.2)	(13)	(6)	(0.1)	(14)	(5)	(9)	(42)	(1)	
8	133	6.77	0	5.3	0.6	35.5	29	2	55.6	1.17	0.05
	(125–150)	(7.75)	(2)	(1.2)	(1.2)	(19)	(2.7)	(12)	(36)	(0.8)	(0.01)
9	128	6.5	41.6	5.6	0.2	11.1	6.5	2	81.4	1.22	0.02
	(110)	(7.1)	(18)	(3)	(0.2)	(14)	(0.05)	(14)	(35)	(0.9)	(<0.02)
10	95	7.64	11.2	4.9	0.9	26.1	11	23	33.7	0.01	0.01
	(115)	(7)	(7.3)	(1.2)	(0.35)	(15)	(2.2)	(23)	(20)	(0.75)	(0.02)
11	98	6.5	13.4	6.72	1.1	19.9	9.5	28	37.9	0.84	0.02
	(110)	(7)	(15)	(4)	(0.9)	(13)	(4)	(50)	(14)	(0.9)	(0.02)
12	83	6.67	7.68	6.7	0.4	22.6	8.8	18	24.2	1.02	0.01
	(120)	(7.2)	(14.4)	(3)	(1.5)	(12.3)	(2)	(28)	(17.6)	(0.9)	(0)
13	47	7.83	0	18.6	0.1	1.1	5.9	45	8.3	0.42	0.05
	(43–45)	(6.5–7.5)	(<0.5)	(<6)	(<0.5)	(<3)	(1)	(<30)	(<5)	(<0.5)	(<0.01)
14	103	6.37	12.6	17	0.9	21.6	8.3	17	47.6	1.24	0.01
	(120–130)	(7.0–7.2)	(20)	(3)	(0.2)	(21)	(1)	(10)	(42)	(1)	(0.02)
15	98	7.21	32	12.3	0.1	9	6.2	38	44.9	1.03	0.02
	(125)	(7.4)	(12)	(3.7)	(1.9)	(28)	(5.5)	(42)	(29)	(0.85)	(0.02)

16	173 (237)	7.74 (8)	50.4 (22)	9.5 (2.4)	1.6 (0.08)	19.9 (30>)	11.7 (2.6)	21 (12)	79 (35)	1 (1)	0.01 (0.01)
17	84 (120)	6.65 (7)	15.5 (10)	3.2 (4.45)	1.2 (1.05)	15.8 (16.79)	9.9 (3.08)	37 (35)	27 (17)	0.7 (0.8)	0.02
18	95 (127)	6.88 (7.2)	4.8 (8)	5.6 (3)	1 (1)	29.5 (22)	9.8 (3)	17 (32)	28.6 (40)	0.56 (1)	0.02
19	103 (100–120)	6.69 (7.2–6.8)	9.6 (20)	5.6 (3)	0.9 (0.3)	23 (20)	5.9 (2)	49	24.2 (12)	0.95 (1)	0.03 (0.01)
20	89 (120)	6.52 (6.5–7.5)	20 (12)	6.2 (4)	0.3 (1)	12.9 (20)	10.6 (1.5)	13 (15)	49.6 (14)	1 (1)	0.01 (0)
Mean SD	96.75 (125) 25.88 (30)	6.867 (7.21) 0.4818 (0.29)	14.5 (12.62) 13.4 (6.06)	11.9 (4.571) 10.5 (4.72)	0.67 (0.82) 0.45 (0.53)	17.28 (18.07) 8.56 (6.58)	9.75 (2.42) 5.40 (1.41)	29.35 (28.03) 25.14 (17.82)	38.8 (26.72) 20.1 (12.17)	0.93 (0.93) 0.34 (0.08)	0.02 (0.01) 0.01 (0.01)
Range	47–173 (100–237)	6.37–7.83 (6.8–8)	0–50.4 (1–22)	2.9–40.3 (1.2–21.1)	0.1–1.6 (0.08–1.9)	1.1–35.5 (3–30)	5.3–29 (0.05–5.5)	2–110 (9–74.5)	5.9–81.4 (1–42)	0.01–1.6 (0.75–1)	0.01–0.05 (0–0.02)

Table A2. Total dissolved salt (TDS) concentration, pH value, and anion- and cation concentrations of water samples of 19 international brands as well as corresponding descriptive statistics. For every concentration or pH value, the label content is indicated below the corresponding real content in parentheses. Units: TDS, Ca, Mg, K, Na, NO_3, SO_4, Cl, F, Fe in ppm; pH: unitless. SD = standard deviation.ǂ GSO guidelines (GSO, 2008);[a] KSA guidelines [18].

	Real (label) content of international brands										
Brand No.	TDS	pH	Ca	Mg	K	Na	NO3	SO4	Cl	F	Fe
1	130 (105)	7.32 (7.2)	24 (18)	19.6 (15)	5.3 (5)	14.1 (18)	6.7 (1)	2 (1)	17.9 (9)	0.01 (0)	0.01
2	167 (150)	7.64 (7.2)	56 (47.6)	27 (99)	0.4 (0.3)	3.5 (1.2)	6.6	3 (2.3)	18.8 (1.7)	0.09 (0.02)	0.01
3	223 (309)	7.17 (7.2)	64 (80)	51.5 (26)	0.7 (1)	5 (5.6)	7.2 (7.3)	19	25.8 (6.8)	0.01	0.07
4	856 (142)	6.11	105.6 (108.21)	54.9 (57.39)	15.8 (22)	76.5 (313.5)	13.5 (4.96)	25	278	1	0.01
5	15	7.77 (7.2)	0 (8.1)	0 (23)	0.3	4.9 (1.1)	6.8 (0.37)	3	7.9 (0.84)	0.22	0.05
6	136 (136)	7.05 (7.8)	56 (35)	14.5 (8.5)	0.6 (1)	7.2 (6)	7.9 (<1)	7 (6)	11 (7.5)	0.63 (0.1>)	0.05 (<0.01)
7	124 (120)	7.16 (7.8)	25 (17)	12.8 (6.2)	1.7	23.6 (11)	8.9	41	37.7 (18)	0.38	0.05 (0.025)
8	108 (130–180)	7.13 (7–8)	27 (20–35)	6.7 (5–12)	0.7 (0.5–1.5)	21.8 (15–25)	7 (0–2)	24 (5–25)	35.7 (20–35)	0.35 (0.03–0.1)	0.04
9	153 (190)	7.24 (7.9)	35.2 (50)	39 (13)	0.7 (1)	6.4 (4)	6.9 (0.5)	17 (4)	14.9 (10)	0.26 (0.2>)	0.06 (<0.5)
10	93 (130)	7.46 (7)	13.3 (11.5)	13.1 (8)	4.2 (6.2)	14.4 (11.6)	14.1 (6.3)	12	22.6 (13.5)	0.64	0.05
11	193 (309)	7.28 (7.2)	43 (80)	25.8 (26)	0.9 (1)	7.8 (6.5)	9 (3.7)	19 (12.6)	17.7 (6.8)	0.29	0.04
12	78	7.44 (7.2)	22.4 (14.5)	6.7 (4.9)	1 (1.9)	10.4 (8.5)	11.1	2 (2.4)	9.9 (2.3)	0.16	0.01
13	123 (158)	7.22 (7.5)	44.8 (38)	33.6 (17)	0.3 (0.6)	2.7 (2.5)	13.1 (2)	7	16.9 (3.5)	0.01 (0.2)	0.01
14	466 (1084)	6.98	256 (240)	44.8 (42)	1.9	6.1 (5.2)	9.9 (4.4)	675 (400)	27.8	0.58	0.02
15	259 (309)	7.26 (7.2)	97.6 (80)	46 (26)	0.8 (1)	7 (6.5/6.5)	10.6 (3.7–3.7)	17 (12.6–12.6)	17.9 (6.8–6.8)	0.01	0.02
16	99 (110)	7.2 (7.3)	28.8 (8)	20.1 (13)	1.7 (2)	9.4 (8)	7.2 (<0.30)	9 (5)	53.6 (40)	0.02 (<0.1)	0.02
17	112 (170)	7.51	38 (32)	17.9 (8)	2.4 (2.2)	7.7 (14)	7.1	19 (13)	19.85 (14)	0	0.01
18	69 (180)	7.64 (8.2)	27	10.2	0.1	3.2 (5.5)	5.7	13 (8.17)	9.9 (1.12)	0.44	
19	87 (115)	7.8 (7.2)	9.4 (6)	14.7 (1)	1.6 (1)	11.1	5.3 (0.1)	56	27.8 (45)	0.2 (0.2)	
20	263 (316)	7.01 (7.34)	72 (35)	56 (23)	9.5 (0.7)	21	6.4 (<0.1)	74	51.6	1.93	
Mean SD	187.7 (237) 184.5 (231)	7.27 (7.40) 0.3646 (0.33)	52.2 (50.5) 55.2 (56.06)	25.7 (23.17) 17.4 (23.52)	2.53 (3.12) 3.83 (5.47)	13.19 (26.39) 16.14 (76.7)	8.55 (3.06) 2.653 (2.62)	52.2 (45.45) 147.8 (124.6)	36.1 (12) 58.3 (13.41)	0.36 (0.12) 0.45 (0.093)	(0.02) (0)
Range	15–856 (105–1084)	6.11–7.8 (7–8.2)	0–256 (6–240)	0–56 (1–99)	0.1–15.8 (0.3–22)	2.7–76.5 (1.1–313.2)	5.3–14.1 (0.1–7.3)	2–675 (1–400)	7.9–278 (0.84–45)	(0–0.2)	(0.02– 0.02)
REFERENCE VALUES	(100–600ǂ)	(6.5–8.0ǂ)	(–)	(<150ǂ)	(–)	(<100a)	(<50ǂ)	(<250ǂ)	(<150a)	(<1.5a)	(<0.3ǂ)

Data availability

All chemical analysis data are included in this manuscript. Additional information about the bacteriological analysis can be obtained from the author at asdablool@uqu.edu.sa.

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A.S.D. conceived of the study, performed all measurements and analyses, and wrote this manuscript.

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References:

1. Gątarska A, Ciborska J, Tońska E. Natural mineral bottled waters available on the Polish market as a source of minerals for the consumers. Part 2: The intake of sodium and potassium. Rocz. Panstw Zakl Hig. 67.4(2016): 4373–4382.
2. GCC Standardization Organization (GSO) Technical Committee: Bottled drinking water, 2008.
3. Alfadul SM., Khan MA. Water quality of bottled water in the kingdom of Saudi Arabia: A comparative study with Riyadh municipal and Zamzam water. J. Environ. Sci. Heal. A, 46.13(2011): 1519–1528.
4. Wright KF. Is your drinking water acidic? A Comparison of the varied pH of popular bottled waters, J. Dent. Hyg., 89.2(2015): 6–12.
5. World Health Organization: Guidelines for Drinking Quality, 3rd ed. Geneva, Switzerland: WHO Press, 2008.
6. Hamad I, Al-Enazi F, Al-Sharari B. Inorganic components in drinking water collected from schools' coolers and some bottled water brands sold on Sakaka markets, Saudi Arabia. Biosci. Res., 8.1(2011): 38–43.
7. Luo Q, Liu ZH, Yin H, Dang Z, Wu PX, Zhu NW, Lin Z, Liu Y. Migration and potential risk of trace phthalates in bottled water: A global situation, Water Research, 147(2018): 362–372.
8. GCC Standardization Organization (GSO) Technical Committee: Labeling for drinking water and Bottled natural mineral water, 2019.
9. Alimohammadi M, Latifi N, Nabizadeh R, Yaghmaeian K, Mahvi AH, Yousefi M, Foroohar, P, Hemmati S, Heidarinejad Z. Determination of nitrate concentration and its risk assessment in bottled water in Iran. Data Brief. 19(2018), 2133–2138.
10. Sharma D, Singh A, Verma K, Paliwal S, Sharma S, Dwivedi J. Fluoride: A review of pre-clinical and clinical studies. Environ. Toxicol. Pharmacol. 56(2017): 297–313.
11. Alshik A. Quality of Bottled Water in the Kingdom of Saudi Arabia: A Comparative Study with Jazan Water and Zamzam Water. New York Sci. J. 6.12(2013):174–180.
12. Kingdom of Saudi Arabian Standards Organization (KSA): Specifications and standard, No 409/1984, 2003.
13. Chowdhury S. Water quality degradation in the sources of drinking water: an assessment based on 18 years of data from 441 water supply systems, Environ. Monit. Assess. 190.7(2018): 379.
14. Amogne WT, Gizaw M, Abera D. Physicochemical quality and health implications of bottled water brands sold in Ethiopia. J. Egypt Public Health Assoc., 90.2(2015):72–79.
15. Guissouma W, Hakami O, Al-Rajab AJ, Tarhouni, J. Risk assessment of fluoride exposure in drinking water of Tunisia. Chemosphere, 177(2017): 102 – 108.
16. Sezgin BI, Onur ŞG, Menteş A, Okutan AE, Haznedaroğlu E, Vieira AR. Two-fold excess of fluoride in the drinking water has no obvious health effects other than dental fluorosis. J. Trace Elem. Med. Biol. 50(2018): 216–222.
17. Egbi CD, Anornu GK, Ganyaglo SY, Appiah-Adjei EK, Li SL, Dampare SB. Nitrate contamination of groundwater in the Lower Volta River Basin of Ghana: Sources and related human health risks. Ecotox. Environ. Safe., 191(2020): 110-227.
18. French Food Safety Agency. Guidelines for the safety assessment of natural mineral waters, 2008.
19. Gątarska A, Ciborska J, Tońska E. Natural mineral bottled waters available on the Polish market as a source of minerals for the consumers. Part 2: The intake of sodium and potassium. Rocz. Panstw Zakl Hig. 67.4(2016): 4373–4382.
20. Ghrefat, H. Classification and evaluation of commercial bottled drinking waters in Saudi Arabia. Res. J. Environ. Earth Sci. 5.4(2013): 210–221.
21. Dharmaratne RW. Fluoride in drinking water and diet: the causative factor of chronic kidney diseases in the North Central Province of Sri Lanka, Environ. Health Prev. 20.4(2015): 237–242.
22. Khater AEM., Al-Jaloud A, El-Taher A. Quality level of bottled drinking water consumed in Saudi Arabia, J. Environ. Sci. Technol. 7.2(2014): 90–106.
23. GCC Standardization Organization (GSO) Technical Committee: Bottled drinking water, 2008.
24. Moazeni M, Atefi M, Ebrahimi A, Razmjoo P, Vahid Dastjerdi M. Evaluation of chemical and microbiological quality in 21 brands of Iranian bottled drinking waters in 2012: a comparison study on label and real contents. J. Environ. Public Health, 2013:469590, 2013.
25. Moslemi M, Khalili Z, Karimi S, Shadkar MM. Fluoride Concentration of Bottled Water and Tap Water in Tehran, Iran. J. Dent. Res. Dent. Clin. Dent. Prospect. 5.4(2011): 132–135.
26. Quattrini, S. Natural mineral waters: chemical characteristics and health effects. Clin. Cases Miner Bone Metab. 13.3(2016): 173–180.
27. Stanič TF, Miler M, Brenčič M, Gosar M. Calcite precipitates in Slovenian bottled waters, Environ. Sci. Pollut. Res. Int. 24.16(2017):14176–14189.
28. World Health Organization: Guidelines for drinking-water quality: first addendum to the third edition, volume 1: recommendations. Geneva: WHO, 2006.
29. Zohouri FV, Maguire A, Moynihan PJ. Fluoride content of still bottled waters available in the North-East of England, UK. Br Dent J., 195.9(2003):515–518.

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