Vol. 14(7), pp. 192-202, July 2020
DOI: 10.5897/AJEST2020.2846
Article Number: 643279564406
ISSN: 1996-0786

http://www.academicjournals.org/AJEST

ACADEMIC JOURNALS
expand your knowledge

African Journal of Environmental Science and Technology

Full Length Research Paper

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

Anas S. Dablool

Department of Public Health, Health Sciences College at Al-Leith, Umm Al-Qura University, Makkah, Saudi Arabia.

Received 16 April, 2020; Accepted 25 June, 2020

For consumers, the water composition is indicated on a label attached to the water bottle. Reports about wrong label information were the motivation for this comparative study of the real content of 20 different bottled water brands from Saudi Arabia and 19 other brands from different countries in Asia, Oceania, Africa, and Europe. The pH, total dissolved salt (TDS) concentration, and concentrations of nine cations and anions were evaluated and bacteriological analysis was carried out to determine for all Saudi and international brands. Bottled water from all tested brands is safe for consumption. Furthermore, the determined analysis agrees with the water parameters 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 international brands. Considering that bottled water consumption has increased, especially in geographic areas where drinking quality tap water is not available, quality control of bottled water becomes essential, aiming for correct information on the label to reliably inform the consumers and ensure human health.

Key words: Bottled water, label, Saudi Arabia, brand.

INTRODUCTION

Access to drinking water is a basic human need, and bottled water has become 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 micronutrients and the amount of total dissolved salts as well as related physical properties (e.g., pH value, electrical conductivity) (Chowdhury, 2018). Furthermore, possible contamination with toxic or radioactive chemicals as well as microorganisms has a negative impact on the water quality (Abada et al., 2019; Almasoud et al., 2020).

Standards for drinking-water quality have been defined by organizations like the World Health Organization (WHO) and the Gulf Cooperation Council (GCC) Standardization Organization (GSO) by indicating reference values for different water components (World

E-mail: asdablool@uqu.edu.sa.

Health Organization, 2006). 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 (Khater et al., 2014). Moreover, high fluoride concentrations present a health risk for children, and boron is a known carcinogen (Al-Omran et al., 2013).

A strict control of bottled water composition is needed to preserve human health and consumers must rely on the information indicated in the attached label to get to know the water quality and its mineral content. 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^{2+}, K^+, Mg^{2+}, and Na^+) and micronutrients (Co^{2+}, Cr^{3+}, Cu^{2+}, Fe^{3+}, Mo, Se, and Zn^{2+}) contents (GCC Standardization Organization, 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. For example, a previous study by Moazeni et al. (2013) showed that Iranian bottled drinking waters often present higher or lower values of some parameters with respect to the labelled amounts.

In Saudi Arabia, water is a highly valuable resource, and Saudi production of desalinated water is the largest in the world, covering 70% of the country's demand (Ahmad and Bajahlan, 2009). Different types of water are consumed by people, including tap (from sea, rivers or underground water) and bottled water, with an increased consumption of bottled water in the last decades (Alfadul and Khan, 2011). Generally, bottled water are obtained from sea and underground waters. Bottled drinking water must be treated and minerals should be added 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 (GCC Standardization Organization, 2019). Hamad et al. (2011) 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, representing potential 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 (Al-Omran et al., 2013).

Providing bottled water with drinking-water quality is highly important. In this regard, reliable labeling of bottled water is also important. Previous studies have shown deviations of real and label content from drinking-water quality which was our motivation to evaluate the real content of water parameters from various companies in Saudi and international bottled water brands. The aim of our study was to analyze Saudi bottled water brands and compare them to international brands. Also, we proposed to study if the label content reflected the real content of Saudi bottled waters. 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^{2+}, Mg^{2+}, Fe^{3+}) and four anions (Cl^-, F^-, nitrate, sulphate) as the basis for our comparison regarding drinking-water standards, label correctness, as well as country-specific differences.

MATERIALS AND METHODS

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

Bottled water samples

Samples were taken from bottled water of 39 commercial brands produced in 15 different countries. From Saudi Arabia, bottled water of the following 20 brands was analyzed (Table 1). Furthermore, bottled water of 19 brands from 14 countries was analyzed (Table 1). 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 (409/1989) (Kingdom of Saudi Arabian Standards Organization, 2003) and Gulf Standard (111/1989) (GCC Standardization Organization (GSO), 2008). Sample analysis was done in triplicate in all cases.

Sample analysis

The pH measurements were performed using a pH meter (HANNA pH 211, Hanna Instruments Italia Srl, Villafranca Padovana, Italy), and total dissolved solids (TDS) concentrations were measured using a TDS meter (HACH Company, Loveland, CO, USA). Concentrations of cations: sodium (Na^+), potassium (K^+), magnesium (Mg^{2+}), calcium (Ca^{2+}), and iron (Fe^{3+}) 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^-), sulphate (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 mg l^{-1}.

Assessment of water quality and comparisons among samples

The parameters measured in the collected samples were compared to the water quality standards proposed by Saudi Arabia Standard (409/1989) (Kingdom of Saudi Arabian Standards Organization,

Table 1. Brands and country of origin of the water bottled used in this study.

Source/Country	Bottle water brand	Volume (ml)
Saudi Arabia	Arwa	500
Saudi Arabia	Afnan	600
Saudi Arabia	Aquafina	600
Saudi Arabia	Azbah	600
Saudi Arabia	Bambini	330
Saudi Arabia	Berain	600
Saudi Arabia	DEEM	600
Saudi Arabia	Fayha	600
Saudi Arabia	Hana	600
Saudi Arabia	Hijra	600
Saudi Arabia	Manahl	600
Saudi Arabia	Manao	250
Saudi Arabia	Mawared	600
Saudi Arabia	Naba	600
Saudi Arabia	Nova	600
Saudi Arabia	Nuran	330
Saudi Arabia	Panda	600
Saudi Arabia	Safa	600
Saudi Arabia	Taiba	600
Saudi Arabia	Tania	600
Croatia	Elite	500
Egypt	Dasani	600
FijiIslands	Fiji	-
Finland	Nord Water	500
France	Evian	500/1000
France	Evian Live	500
France	Vittel	750
France	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
Turkey	Pinarim	330
UnitedArabEmirates	Alain	500
UnitedArabEmirates	Jeema	600

2003) and Gulf Standard (111/1989) (GCC Standardization Organization (GSO), 2008). In addition, the results from Saudi brands were compared to those of international brands. On the other hand, the results obtained after sample analysis were compared to those reported in the corresponding labels.

Bacteriological analysis

Samples were filtered through 0.45 µm pore sized filters and membranes were placed on Petri dishes containing appropriate selective media to evaluate *Escherichia coli* presence. The plates were incubated at 37°C during 24 h. Colonies from presumptive coliforms were enumerated. The results were expressed as number of colony forming units per 1 ml of water.

Statistical analysis

Results were expressed as mean ± standard deviation (SD). Statistical analysis was performed by using SPSS software. A descriptive statistical analysis was carried out and to compare bottled water sample parameters between real content and label content ANOVA comparisons were performed. A p-value below

0.05 was considered statistically significant.

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. 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^{3+}) concentrations were measured, and the results are presented in Appendix Tables A1 to A4. Furthermore, Tables A1 to A4 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 Organization (GSO), 2008). However, one brand from France exceeded the 600 mg l^{-1} reference limit by exhibiting a real TDS value of 1084 mg l^{-1}, while only 466 mg l^{-1} was 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 sulphate reference value of 250 mg l^{-1} with a real value of 400 mg l^{-1}. Furthermore, the real sulphate content was lower compared with its label content of 675 mg l^{-1}. Only one sample from Morocco exhibited a higher chloride concentration of 278 mg l^{-1}. 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 mg l^{-1}, 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 mg l^{-1} limit.

WHO and GSO do not define a reference range for the sodium content in bottled water. Nonetheless, KSA guidelines indicated a 100 mg l^{-1} limit, which was respected in all tested samples, while the Morocco brand declared sodium content on the bottled label that was 3-fold higher than the established limit. However, the measured value was only 76 mg l^{-1}, 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^{2+}, Mg^{2+}, K^+, Na^+, Fe^{3+}) and anion (SO_4^{2-}, NO_3^-, Cl^-, F^-) concentrations were calculated for bottled water samples from the 20 Saudi brands and the 19 international brands, as depicted in Figure 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 (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 Figure 2a and b, respectively. These comparisons revealed that for both Saudi and international brands, almost all measured parameters (Figure 2a) were closed 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 (Figure 2b).

Comparison real/label content difference in Saudi Arabia vs. international brands

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

Bacteriological analysis

In addition to the analysis of salt content and pH value presented earlier, bacteriological analyses for *E. coli* and coliform bacteria were performed, as also a bacterial contamination of bottled water presents a possible hazard for human health. However, the results analysis showed that all 39 samples were negative for *E. 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, 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

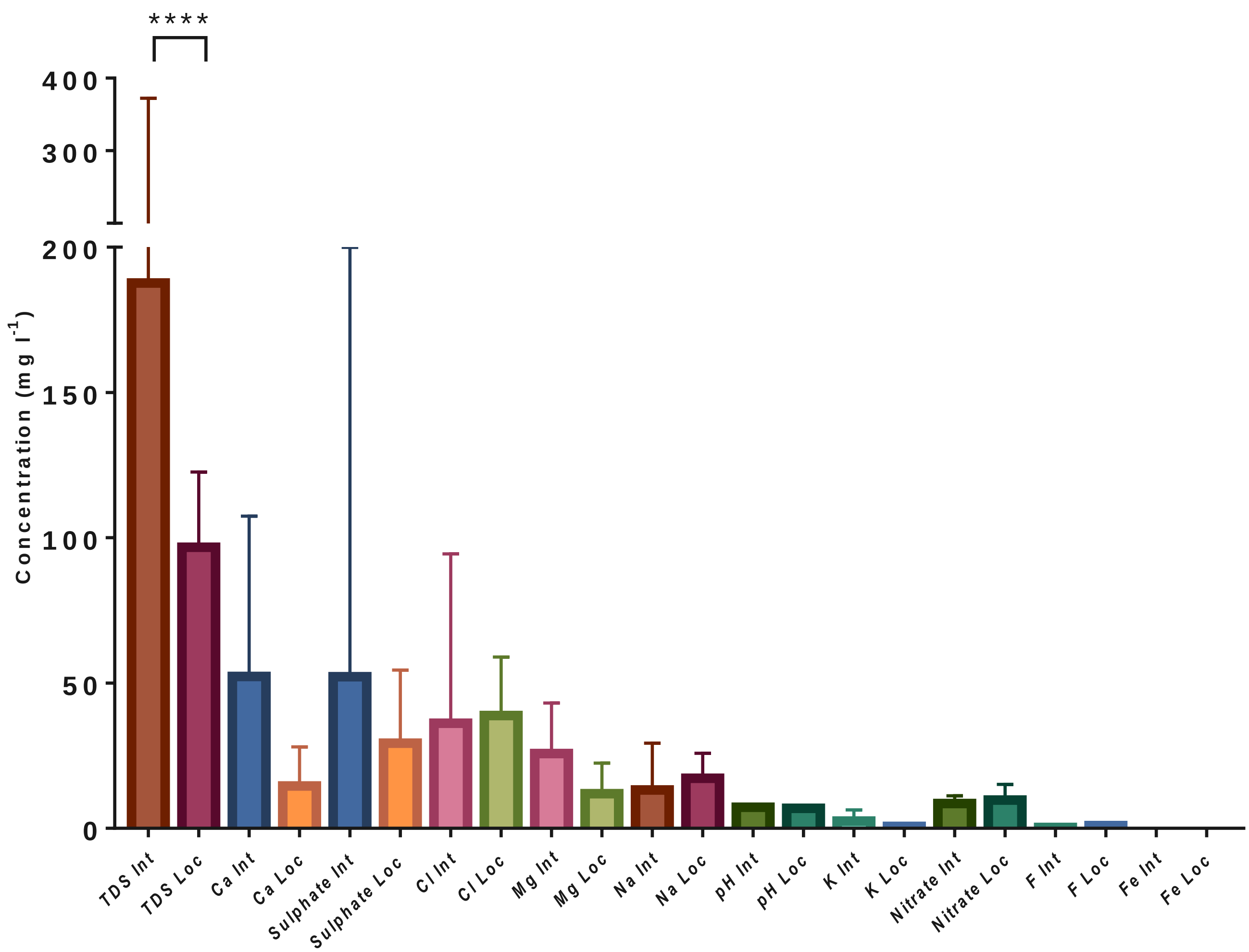

Figure 1. Comparison between the real contents in bottled water from Saudi Arabia (loc) and international brands (int).

Europe were compared. 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 other 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 within the guidelines established either by GSO, WHO, or KSA.

Some previous 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 (2011) reported discrepancies among real and label content in water samples for both Saudi brands and international brands. 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 (Amogne et al., 2015). Al-Omran et al. (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 et al. (2017) revealed that the storage conditions of the bottles may also alter the water composition. High temperatures might stimulate crystal formation and precipitation depending on the composition of the water. The authors indicated that the presence of Mg^{2+}, SO_4^{2-}, 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.

In this study it was shown that one natural mineral water sample from France exhibited higher levels of TDS and sulphates than proposed by the GSO. However, TDS French guidelines recommend different mineral water contents than WHO and GSO (French Food Safety Agency, 2008). Although there are no reference limits for TDS, French guidelines suggest a mineral content classification between very low, low, and rich for fixed

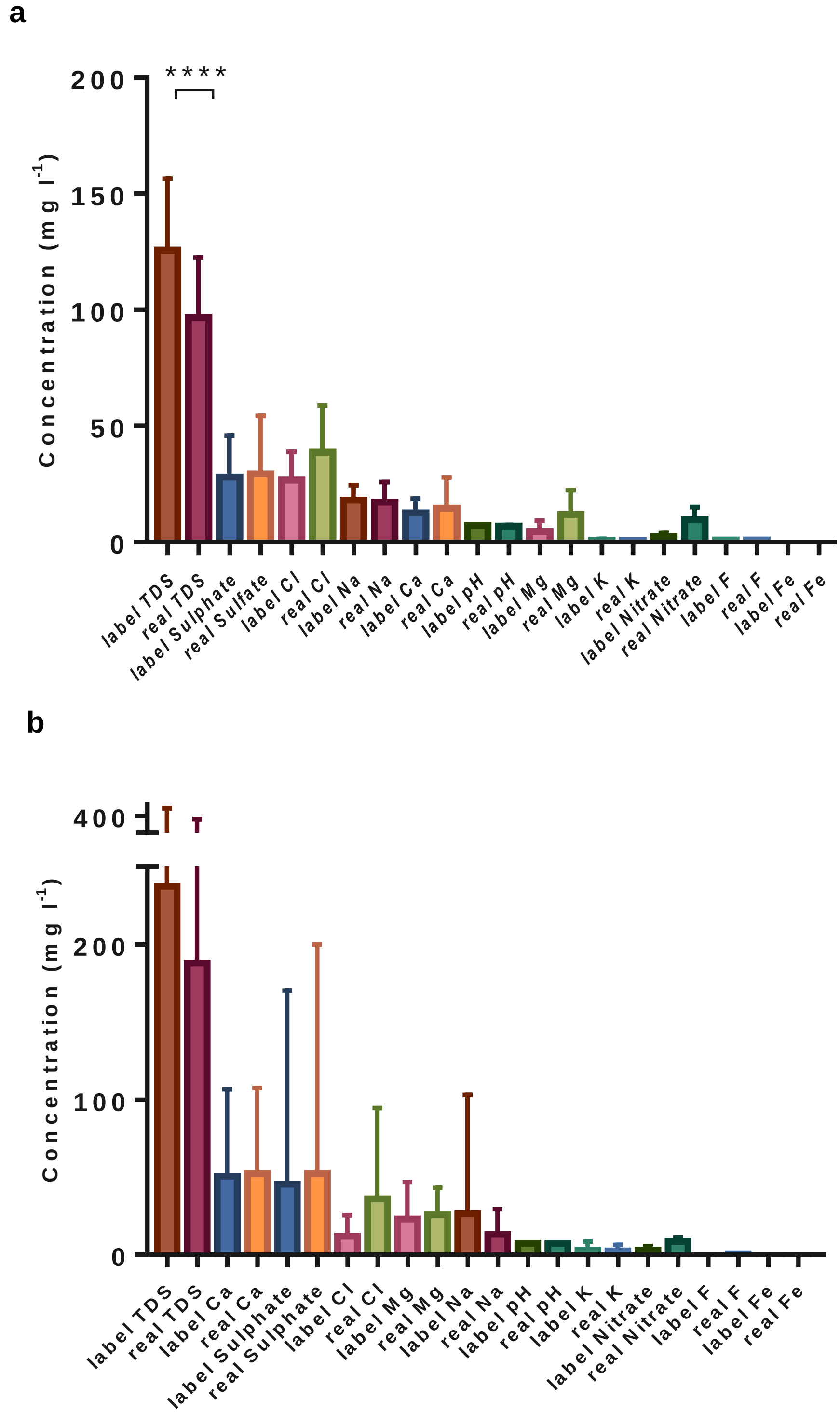

Figure 2. ANOVA comparison between label and real content in bottled water samples from Saudi brands (a) and international brands (b).

residues below 50 mgl^{-1}, below 500 mgl^{-1}, and above 1500 mgl^{-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. It should be noted however, that French guidelines allow a greater TDS content. Furthermore, the TDS varies

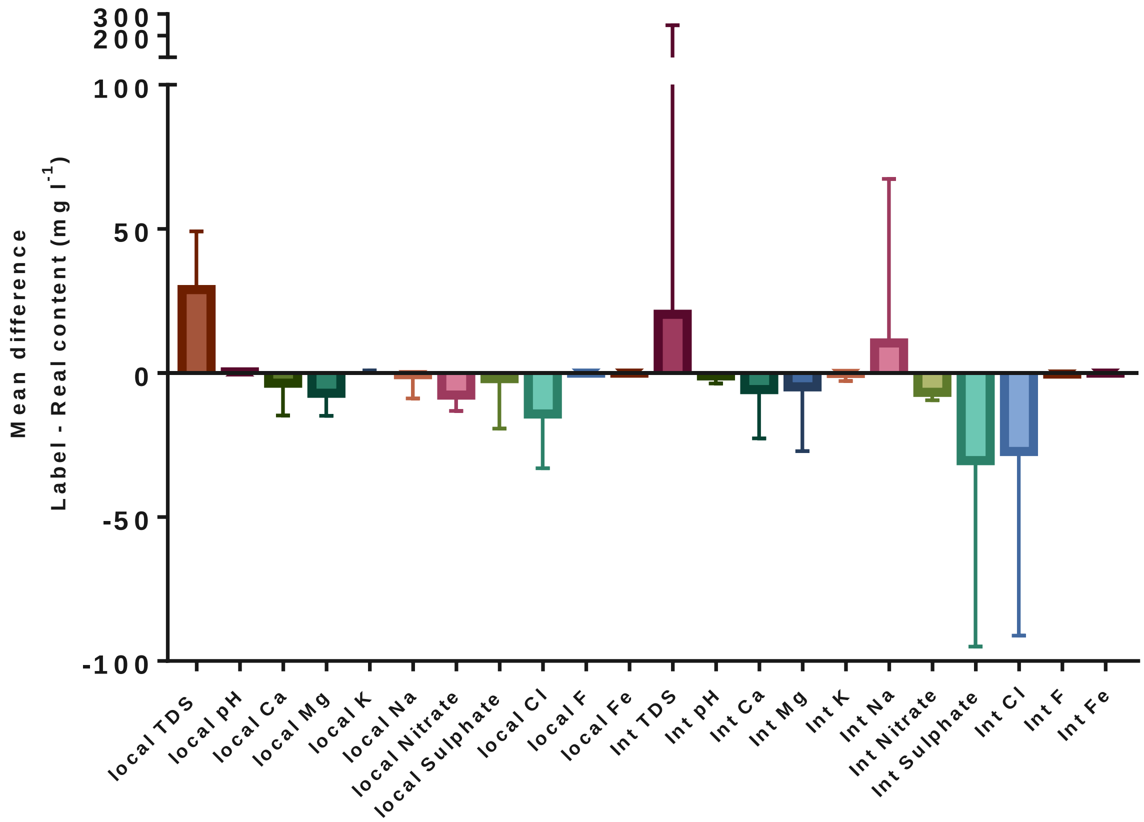

Figure 3. Comparison of the mean difference between label and real content (real content subtracted from label content) in Saudi brands vs. international brands.

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 French Food Safety Agency (2008). There is paucity of information about health effect of TDS but according to World Health Organization (2008), high levels might affect consumers' acceptability. In contrast, TDS was found to be the only parameter that was significantly lower in bottled water samples from Saudi brands compared to international brands. Even more, the real content of TDS in Saudi brand samples were lower than the label content. These differences may also be 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 earlier.

The higher sulphate concentration in one French bottled water sample may be explained by French guidelines, which value high sulphate concentrations of more than 200 mg l^{-1} by classifying such water as "sulphate water". It has been reported that sulphate has beneficial effects on human health and is considered a macronutrient (Quattrini et al., 2016). However, sulphate can affect the water taste and even cause a laxative effect, but the taste is only slightly affected if the sulphate level is below 250 mg l^{-1} (World Health Organization, 2008; Ghrefat, 2013).

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 mg l^{-1}, 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 (Quattrini et al., 2016). 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 (Gątarska et al., 2016). The results of our study showed that only the Moroccan water brand had the highest sodium content of 76 mg l^{-1}, is within the KSA reference limit. The GSO proposed to mark sodium contents below 20 mg l^{-1} by indicating the phrase “low sodium content” on the label.

Fluoride has a relevant function in bone health and prevention of dental caries (World Health Organization, 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 (Quattrini et al., 2016; Guissouma et al., 2017), and a maximum value of 1.5 mg l^{-1} 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 to 13 years old (Sezgin et al., 2018). In fact, fluorosis is the only confirmed negative effect on health although harmful effects on bones, kidneys, muscles, and nerves have been suggested (Dharmaratne, 2015; Sharma et al., 2017). In this study, it was shown that for most tested brands fluoride levels within the 1.5 mg l^{-1} limit. Only the measured fluoride level of two brands from Saudi Arabia and Jordan exhibited values higher than the 1.5 mg l^{-1} limit but still below 2 mg l^{-1}. 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 (Moslemi et al., 2011).

No health-based guidelines have been proposed by WHO (2008) or GSO (GCC Standardization Organization (GSO), 2008) for the chloride content in bottled water, although excessive chloride over 250 mg l^{-1} has been associated with salty taste. Almost all samples obeyed the standards of the Kingdom of Saudi Arabia (KSA, 2003), which indicate that the chloride content should be below 150 mg l^{-1}.

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 (Chowdhury, 2018). Changes in the composition of the water sources could cause new challenges in water treatment. These observations suggest than a strict control of bottled water is needed in order to guarantee safe water provision, thus avoiding water with undesired substances or low levels of desired compounds.

Conclusion

The results showed that all samples were in terms of 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, of international standards, and their label analysis is reliable.

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.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

REFERENCES

Abada E, Al-Fifi Z, Al-Rajab AJ, Mahdhi M, Sharma M (2019). Molecular identification of biological contaminants in different drinking water resources of the Jazan region, Saudi Arabia. Journal of Water Health 17(4):622-632.

Ahmad M, Bajahlan AS (2009). Quality comparison of tap water vs. bottled water in the industrial city of Yanbu (Saudi Arabia). Environmental Monitoring and Assessment 159:1-14.

Al-Omran AM, El-Maghraby SE, Aly AA, Al-Wabel MI, Al-Asmari ZA, Nadeem ME (2013). Quality assessment of various bottled waters marketed in Saudi Arabia. Environmental Monitoring and Assessment 185:6397-6406.

Alfadul SM, Khan MA (2011). Water quality of bottled water in the kingdom of Saudi Arabia: A comparative study with Riyadh municipal and Zamzam water. Journal of Environmental Science and Health. Part A, Toxic/Hazardous Substances and Environmental Engineering 46:1519-1528.

Almasoud FI, Ababneh ZQ, Alanazi YJ, Khandaker MU, Sayyed MI (2020). Assessment of radioactivity contents in bedrock groundwater samples from the northern region of Saudi Arabia. Chemosphere 242:125181.

Amogne WT, Gizaw M, Abera D (2015). Physicochemical quality and health implications of bottled water brands sold in Ethiopia. The Journal of the Egyptian Public Health Association 90:72-79.

Chowdhury S (2018). Water quality degradation in the sources of drinking water: An assessment based on 18 years of data from 441 water supply systems. Environmental Monitoring and Assessment 190:379.

Dharmaratne RW (2015). Fluoride in drinking water and diet: the causative factor of chronic kidney diseases in the North Central Province of Sri Lanka. Environmental Health and Preventive Medicine 20:237-242.

French Food Safety Agency (2008). Guidelines for the safety assessment of natural mineral waters.

Gątarska A, Ciborska J, Tońska E (2016). 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. RocznikiPanstwowegoZakladuHigieny67:4373-4382.

GCC Standardization Organization (2019). Technical Committee: Labeling for drinking water and Bottled natural mineral water.

GCC Standardization Organization (GSO) (2008). Technical Committee: Bottled drinking water.

Ghrefat H (2013). Classification and Evaluation of Commercial Bottled Drinking Waters in Saudi Arabia. Research Journal of Environmental and Earth Sciences 5:210-218.

Guissouma W, Hakami O, Al-Rajab AJ, Tarhouni J (2017). Risk assessment of fluoride exposure in drinking water of Tunisia. Chemosphere 177:102-108.

Hamad I, Alanazi F, Al-Sharari B (2011). Inorganic components in drinking water collected from schools coolers and some bottled water brands sold on Sakaka markets, Saudi Arabia. Bioscience Research 8(1):38-43.

Khater A, Al-Jaloud A, El-TaherA (2014). Quality level of bottled drinking water consumed in Saudi Arabia. Journal of Environmental Science and Technology 7:90-106.

Kingdom of Saudi Arabian Standards Organization (KSA) (2003). Specifications and standard, No 409/1984

Moazeni M, Atefi M, Ebrahimi A, Razmjoo P, Vahid Dastjerdi M (2013). Evaluation of chemical and microbiological quality in 21 brands of Iranian bottled drinking waters in 2012: A comparison study on label and real contents. Journal of Environmental and Public Health 2013:469590.

Moslemi M, Khalili Z, Karimi S, Shadkar MM (2011). Fluoride concentration of bottled water and tap water in Tehran, Iran. Journal of Dental Research, Dental Clinics, Dental Prospects 5:132-135.

Quattrini S, Pampaloni B, Brandi ML (2016). Natural mineral waters: Chemical characteristics and health effects. Clinical Cases in Mineral and Bone Metabolism: The Official Journal of the Italian Society of Osteoporosis, Mineral Metabolism, and Skeletal Diseases 13:173-180.

Sezgin BI, Onur ŞG, Menteş A, Okutan AE, Haznedaroğlu E, Vieira AR (2018). Two-fold excess of fluoride in the drinking water has no obvious health effects other than dental fluorosis. Journal of Trace Elements in Medicine and Biology : Organ of the Society for Minerals and Trace Elements (GMS) 50:216-222.

Sharma D, Singh A, Verma K, Paliwal S (2017). Fluoride: A review of pre-clinical and clinical studies. Environmental Toxicology and Pharmacology 56:297-313.

Stanič TF, Miler M, Brenčič M, Gosar M (2017). Calcite precipitates in Slovenian bottled waters. Environmental Science and Pollution Research International 24:14176-14189.

World Health Organization (WHO) (2006). Guidelines for drinking-water quality: First addendum to the third edition, volume 1: Recommendations. WHO Press, Geneva.

World Health Organization (WHO) (2008). Guidelines for Drinking Quality, 3rd edn. WHO Press, Geneva.

APPENDIX

Table A1. Descriptive analysis of Total dissolved salt (TDS) concentration, pH value, and anion- and cation concentrations of water samples of 20 Saudi brands.

Brand no.	Real (label) content of Saudi brands										
	TDS	pH	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	NO_3^-	SO_4^{2-}	Cl^-	F^-	Fe^{3+}
Mean	96.75 (125)	6.867 (7.21)	14.5 (12.62)	11.9 (4.571)	0.67 (0.82)	17.28 (18.07)	9.75 (2.42)	29.35 (28.03)	38.8 (26.72)	0.93 (0.93)	0.02 (0.01)
SD	25.88 (30)	0.4818 (0.29)	13.4 (6.06)	10.5 (4.72)	0.45 (0.53)	8.56 (6.58)	5.40 (1.41)	25.14 (17.82)	20.1 (12.17)	0.34 (0.08)	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)

For every concentration or pH value, the label content is indicated below the corresponding real content in parentheses. Units: TDS, Ca^{2+}, Mg^{2+}, K^+, Na^+, NO_3^-, SO_4^{2-}, Cl^-, F^-, Fe^{3+} in mg l^{-1}. SD = standard deviation.[‡] GSO guidelines (GSO, 2008);[a]KSA guidelines (KSA, 2003).

Table A2. Descriptive analysis of Total dissolved salt (TDS) concentration, pH value, and anion- and cation concentrations of water samples of 19 international brands.

Brand no.	Real (label) content of International brands										
	TDS	pH	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	NO_3^-	SO_4^{2-}	Cl^-	F^-	Fe^{3+}
Mean	187.7 (237)	7.27 (7.40)	52.2 (50.5)	25.7 (23.17)	2.53 (3.12)	13.19 (26.39)	8.55 (3.06)	52.2 (45.45)	36.1 (12)	0.36 (0.12)	(0.02)
SD	184.5 (231)	0.3646 (0.33)	55.2 (56.06)	17.4 (23.52)	3.83 (5.47)	16.14 (76.7)	2.653 (2.62)	147.8 (124.6)	58.3 (13.41)	0.45 (0.093)	(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	(100-600[‡])	(6.5-8.0[‡])	(-)	(<150[‡])	(-)	(<100a)	(<50[‡])	(<250[‡])	(<150[a])	(<1.5[a])	(<0.3[‡])

For every concentration or pH value, the label content is indicated below the corresponding real content in parentheses. Units: TDS, Ca^{2+}, Mg^{2+}, K^+, Na^+, NO_3^-, SO_4^{2-}, Cl^-, F^-, Fe^{3+} in mg l^{-1}; pH. SD = standard deviation.[‡] GSO guidelines (GSO, 2008);[a]KSA guidelines (KSA, 2003).

Table A3. Results of all parameters analyzed in Saudi brand samples. Results are expressed in mg l^{-1}.

Brand no.	Real (label) content of Saudi brands										
	TDS	pH	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	NO_3^-	SO_4^{2-}	Cl^-	F^-	Fe^{3+}
1	84 (121)	6.7 (6.8)	0 (1.0>)	40.3 (21.1)	0.5 (1>)	3.3 (3)	5.9 (1>)	110 (74.5)	5.9 (1.0>)	1.1 (1.2–0.8)	0.01
2	104 (115)	6.5 (7.1)	15.8 (10)	14.7 (2.3)	1.2 (1)	21.7 (29)	18.1 (3.4)	34 (28)	41.5 (35)	1.6 (1)	0.02
3	96 (110)	6.57 (7)	4.8 (<5)	28 (13)	1.2 (1)	12.4 (16)	6.3 (<0.1)	67 (51)	31.8 (27.5)	0.98 (1)	0.02 (0.01)
4	92 (127)	6.6 (7.2)	3.5 (8)	6.8 (3)	0.6 (1)	22.1 (22)	9.2 (3)	14 (32)	25.8 (40)	0.81 (1)	0.05
5	87 (120)	6.64 (7.2)	12.6 (14.4)	32.6 (3)	0.4 (1.5)	16.5 (12.3)	9.9 (2)	32 (28)	63.5 (17.5)	0.81 (0.9)	0.02 (0.0)
6	67 (135)	6.6 (7.2)	16 (20)	2.9 (2.5)	0.1 (0.25)	11.7 (16)	5.3 (1)	9 (9)	23.9 (33)	0.88 (1)	0.02 (0)
7	76 (100)	7.76 (7.2)	20 (13)	5.9 (6)	0.1 (0.1)	9.8 (14)	7.2 (5)	11 (9)	41.7 (42)	1.29 (1)	0.05
8	133 (125-150)	6.77 (7.75)	0 (2)	5.3 (1.2)	0.6 (1.2)	35.5 (19)	29 (2.7)	2 (12)	55.6 (36)	1.17 (0.8)	0.05 (0.01)
9	128 (110)	6.5 (7.1)	41.6 (18)	5.6 (3)	0.2 (0.2)	11.1 (14)	6.5 (0.05)	2 (14)	81.4 (35)	1.22 (0.9)	0.02 (<0.02)
10	95 (115)	7.64 (7)	11.2 (7.3)	4.9 (1.2)	0.9 (0.35)	26.1 (15)	11 (2.2)	23 (23)	33.7 (20)	0.01 (0.75)	0.01 (0.02)
11	98 (110)	6.5 (7)	13.4 (15)	6.72 (4)	1.1 (0.9)	19.9(13)	9.5 (4)	28 (50)	37.9 (14)	0.84 (0.9)	0.02 (0.02)

Table A3. Contd.

12	83 (120)	6.67 (7.2)	7.68 (14.4)	6.7 (3)	0.4 (1.5)	22.6 (12.3)	8.8 (2)	18 (28)	24.2 (17.6)	1.02 (0.9)	0.01 (0)
13	47 (43-45)	7.83 (6.5-7.5)	0 (<0.5)	18.6 (<6)	0.1 (<0.5)	1.1 (<3)	5.9 (1)	45 (<30)	8.3 (<5)	0.42 (<0.5)	0.05 (<0.01)
14	103 (120-130)	6.37 (7.0-7.2)	12.6 (20)	17 (3)	0.9 (0.2)	21.6 (21)	8.3 (1)	17 (10)	47.6 (42)	1.24 (1)	0.01 (0.02)
15	98 (125)	7.21 (7.4)	32 (12)	12.3 (3.7)	0.1(1.9)	9 (28)	6.2(5.5)	38 (42)	44.9 (29)	1.03 (0.85)	0.02 (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)

Table A4. Results of all parameters analyzed in international brand samples. Results are expressed in mg l^{-1}.

Brand no.	Real (label) content of International brands										
	TDS	pH	Ca^{2+}	Mg^{2+}	K^+	Na^+	NO_3^-	SO_4^{2-}	Cl^-	F^-	Fe^{3+}
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	
Reference values	(100-600‡)	(6.5-8.0‡)	(-)	(<150‡)	(-)	(<100a)	(<50‡)	(<250‡)	(<150a)	(<1.5a)	(<0.3‡)