



Study on physicochemical properties of domestic bottled drinking water brands in Saudi Arabia

KEYWORDS

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ABSTRACT *Physicochemical properties (pH, electric conductivity and total hardness), positive cations (magnesium, sodium, calcium and potassium) and negative anions (chloride, sulphates, Bromate, nitrate and iron) of different domestic bottled water brands in Kingdom of Saudi Arabia were analysed using standard methods. These parameters were compared with the guideline value of Saudi standards. Results indicated that the quality of bottled water samples was within the permissible limit.*

1. Introduction

Water consumed by human comes in various forms and from the various sources, bottled water was once from that forms (Hussein et al., 2014). Bottled water can be defined as natural mineral water – that is, “water that originates from an underground layer or repository, comes from one or more natural or artificial springs and has particularly hygienic characteristics and perhaps properties which are beneficial to health” (Mosca et al., 2006). In other definition, bottled water is any potable water that is manufactured, distributed or offered for sale, which is sealed in food-grade bottles or other containers and intended for human consumption (Warburton, 2000). It is generally perceived as pure, clean, of good quality and protected (Li et al., 2004). Bottled water is usually manufactured and marketed by standard companies, both local and multinational. These waters are either drawn from natural springs, or deep boreholes and treated according to the specifications by passing through various filters and disinfected appropriately (Ajayi et al., 2008).

In recent years, coping with the modern human lifestyle, there has been a remarkable increase in consumers demand for bottled waters worldwide including Saudi Arabia (Al Hazzani et al., 2013), however, their worldwide sales increased of more than 35 billion \$, largely because of the public perception of purity and safety and public concern about the quality of tap water (Raj, 2005). In Saudi Arabia, there are more than 90 registered manufacturers providing and packaging drinking water (Al Hazzani et al., 2013) as bottled water is widely sold and consumed in Riyadh, Saudi Arabia and is preferred over tap water (Nounou et al., 2013).

Because bottled water is often a significant part of the water consumed by the public, it has been urged that it should meet the same standards as tap water for its contents levels (Lalumandier and Ayers, 2000). Thus in the Kingdom of Saudi Arabia, the quality of bottled water is currently receiving more attention by Saudi Arabian Standards Organization (SASO). However, SASO (2009) developed bottled water standards to define a quality of water that is safe and acceptable to the consumer. These standards set limits for the permissible and the maximum contaminant level of chemical elements and indicator organisms that endanger the health of consumers (Al-Redhaiman and Abdelmagid, 2002). Besides this standard limits, quality of bottled water is subjected to intensive

investigation in Saudi Arabia, in order to evaluate its suitability for human consumption as the studies conducted by (Alabdula'aly and Khan, 1995; Al-Saleh and Al-Doush, 1998; Alabdula'aly and Khan, 1999; Zahid, 2003; Tayyeb et al., 2004; Abed and Alwakeel, 2007; Ahmad and Bajahlan, 2009; Al-Otaibi and Zaki, 2009; Khan and Chohan, 2010; Aldrees and Al-Manea, 2010; Alfadul and Khan, 2011; Al Hazzani et al., 2013; Ghrefat, 2013; Al-Omran et al., 2013; Alshikh, 2013; Aly et al., 2013; Nounou et al., 2013; Nouri et al., 2014). However, the quality of water may vary from one source to another based on several parameters such as water sources, type of water purification and storage tanks (Batarseh, 2006).

The main source of bottled water sold in Saudi Arabia is from springs, wells and surface water (Dabloom et al., 2013) and the daily maximum temperature in country varied between a minimum of 21°C and a maximum of 49°C (Rehman and Al-Hadhrani, 2012). On the other hand, the bottled water quality may be affected by the source, treatment type, container type and length of storage (Alabdula'aly and Khan, 1999) and also sun light exposure and temperature of storing cause changes in all physicochemical properties of water in the plastic bottle (Muhamad et al., 2011; Toma et al., 2013). Due to storage of bottled water, in different conditions, is a very common practice among grocery shops. Therefore, it is necessary to study the quality parameters of the bottled water to determine any changes occurring during storage in different locations. So, this paper aims to present the physicochemical water quality of domestic bottled water brands in Kingdom of Saudi Arabia. Comparisons of the results to Saudi standards are presented.

2. Materials and Methods

2.1 Collection of drinking bottled water samples

Sixteen various brands of local bottled drinking water from different retail shops in Riyadh area (Carrefour, Othaim markets,...) with different capacities are collected during July 2013. These samples of bottled drinking water were purchased and unrefrigerated. In addition, these bottles have been produced one month ago and a validity date of one year. All samples were stored in the grocery stores where they are sold at air conditioning room temperature. Each brand name and volume are given in Table (1) according to the brands label, it was sold in (20 – 600) ml size in poly ethylene non-recyclable bottles, two samples are taken from each brands. All these brands were ana-

lysed by measuring physical and parameters to ascertain their compellability with the prescribed/recommended limits of the World Health Organization and Saudi Arabian Standards Organization Standard.

2.2 Analysis procedures

The concentrations of all cations and anions :chloride (Cl), calcium (Ca), magnesium (Mg), sulphate (SO₄), sodium (Na), potassium (K), iron (Fe), nitrate (NO₃) and Bromate (BrO₃) in water are measured by inductively coupled plasma-atomic emission spectrometry (ICP) and LCALL besides total hardness (TH). Meanwhile, pH and electric conductivity (EC) were measured using a bench top pH-meter and conductivity-meter.

3. Results and Discussion

3.1. Chemical characteristics of bottled waters

Water quality parameters of the bottled water samples were analysed after purchasing them from the local market in Riyadh region. Physicochemical properties, positive cations and negative anions are illustrated in Table (1) and Table (2) with minimum and maximum values. The numbers shown are average measurements of two samples for each water brand. Comparison of these values with those set by the Saudi Arabian Standards Organization (SASO, 2009) and the World Health Organization (WHO, 2008) are also shown in Table (3). The result shown in both Table (1) and Table (2) shows the chemical parameters in the investigated bottled drinking water brands demonstrated wide variations in composition, which could be attributed to natural environment from which the water is taken (geological setting, climate, topography, etc.), source water composition and type of treatments applied during their production (Ghrefat, 2013). Additional changes in the water chemistry may also occur during storage and transportation, especially when bottles become exposed to direct sunlight (Guler et al., 2002).

Table (1). Brand name, volume and pH, EC, TH, Cl, SO₄ and Ca concentrations of bottled water samples with minimum and maximum values.

Brand name	Volume (ml)	pH	EC (µs/cm)	TH (mg/L)	Cl (mg/L)	SO ₄ (mg/L)	Ca (mg/L)
Aquafina	330	8.09	297	10	36.00	24.61	63.80
Aquafina	600	7.81	264	36	23.62	61.62	0.02
Alqassim	330	7.56	265	222	142.00	33.00	55.00
Alqassim	600	7.68	277	63	44.61	32.94	12.45
Fayha	330	7.41	281	45	43.46	27.84	7.62
Fayha	600	7.41	275	65	41.15	40.45	12.23
Nestle	600	7.45	420	125	90.32	20.48	35.19
Nova	330	7.80	229	75	44.25	24.60	15.73
Nova	600	8.09	297	70	44.18	18.85	15.39
Hana	330	7.51	433	55	19.64	28.70	7.42

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AlHada (cup)	250	7.57	269	75	39.04	13.48	14.52
Haly (cup)	250	7.57	269	55	33.69	48.57	11.77
Manhal	20	7.44	214	75	39.04	13.48	14.52
Safa	20	8.01	269	110	28.19	34.02	9.97
Valey	20	8.03	284	110	28.19	34.02	9.97
Minimum		7.41	214	10	19.64	13.48	0.02
Maximum		8.09	433	222	142.00	61.62	63.80
Average		7.68	299	77.88	44.81	30.34	18.31

The pH values for all samples fluctuated between 7.41 to 8.09 (Table 1).The limit of pH value for drinking water according to SASO (2009) is specified as 6.5 to 8.5. The pH shows slightly alkaline trend. Generally pH of water is influenced by geology of catchments area and buffering capacity of water (Muhamad et al., 2011). The electrical conductivity results of bottled water samples showed high variation, which ranged from 214 to 433 µS/cm (Table 1) which were lower than recommended level (750µS/cm, Sasikaran et al., 2012). The EC of the water samples is an indicator of their salinity. A high value for electrical conductivity generally means a high degree of salinity and a low value shows that the salinity is low .The mean value of EC is 299 µS/cm and this implies that the waters are not saline. The total hardness results of bottled water samples showed high variation, which ranged from 10 to 222 mg/L (Table 1) all samples expect Alqassim brand (330 ml) are within the Saudi standard limit for bottled water (200 mg/L).

Table (2). Brand name, volume and Mg, Na, BrO₃, K, NO₃ and Fe concentrations of bottled water samples with minimum and maximum values.

Brand name	Volume (ml)	Mg (mg/L)	Na (mg/L)	BrO ₃ (µg/L)	K (mg/L)	NO ₃ (mg/L)	Fe (mg/L)
Aquafina	330	0.02	14.13	<10	1.05	0.00	1.31
Aquafina	600	14.34	15.01	<10	1.04	0.00	1.24
Alqassim	330	41.96	30.38	<10	1.40	22.66	14.61
Alqassim	600	1.48	24.27	<10	0.67	0.00	1.39
Fayha	330	2.52	25.12	<10	0.83	6.11	1.42
Fayha	600	3.56	18.59	<10	0.59	0.00	1.44
Nestle	600	4.13	17.40	<10	0.10	0.09	1.47
Nova	330	4.59	9.77	<10	0.02	0.46	1.47
Nova	600	3.61	11.04	<10	0.02	0.57	1.46
Hana	330	2.56	18.77	<10	0.45	4.65	1.40
Hana	600	2.56	18.77	<10	0.45	4.65	1.40
AlHada(cup)	250	2.50	13.14	5.41	0.08	0.10	1.48
Haly (cup)	250	4.25	21.51	<10	1.04	0.00	1.46
Manhal	20	2.50	13.14	5.41	0.08	0.10	1.48
Safa	20	2.35	22.19	<10	1.03	0.03	1.34
Valey	20	2.35	22.19	<10	1.03	0.03	1.44
Minimum		0.02	9.77	5.41	0.02	0.00	1.24
Maximum		41.96	30.38	5.41	1.40	22.66	14.61
Average		5.95	18.46	5.41	0.62	2.47	2.24

Table (3). Quality of bottled drinking water in Saudi

Arabia compared to the local and international standards.

Parameter	Investigated water brands	SASO (2009)	WHO (2008)
pH	7.41-8.09	6.5-8.50	6.5-8.5
EC (μ S/cm)	214-433	---	---
Ca (mg/L)	0.02-63.80	200	100
Mg (mg/L)	0.02-41.96	150	50
Na (mg/L)	9.77-30.38	100	200
K (mg/L)	0.02-1.40	---	12
SO ₄ (mg/L)	13.48-61.62	150	250
NO ₃ (mg/L)	0.00-22.66	50	50
Cl (mg/L)	19.64-142	150	250
TH (mg/L)	10-222	200	500
BrO ₃ (mg/L)	<10	10	---
Fe (mg/L)	1.24-14.61	0.3	0.3

SASO: Saudi Arabian Standards Organization.

WHO: World health organization.

Concentrations of Mg range from 0.02 to 41.96 mg/L (Table 1) with an average value of 5.59 mg/L. All the water brands have Mg levels well within the Saudi standard limits (150 mg/L, Table 3).

Concentrations of Na varied from 9.77 to 30.38 mg/L with an average value of 18.46 mg/L (Table 2). None of the values exceeded the maximum limit of 100 mg/L set by SASO (2009) (Table 3). Most of the water brands contain lower amounts of Na concentration. An excess of Na concentration over maximum limit of in drinking water may cause a salty taste or odor, as well as some long-term health effects (Derry et al., 1990, Nouri et al., 2014).

Concentrations of Ca ranged between 0.02 to 63.80 mg/L (Table 1) with an average value of 18.31 mg/L. All the studied water brands have Ca levels falling within the Saudi standard limits (200 mg/L, Table 3). Natural water sources typically contain concentrations of up to 10 mg/L Ca and the taste threshold for the Ca is in the range from 100 to 300 mg/L, depending on the associated anion, but higher concentrations are acceptable is consumed (Ghrefat, 2013).

K concentration varies between 0.02 to 1.4 mg/L (Table 2) in the studied brands. No any brands exceed the 12 mg/L level recommended by WHO (2008) standards. Chloride ion is one of the major inorganic anions in water.

Chloride is a salt compound resulting from the combination of the gas, chlorine, and metal. The chloride results of bottled water samples in this study showed high variation, which ranged from 19.64 to 142 mg/L (Table 1) and the chloride concentration is lower than recommended level (150 mg/L, Table 3).

The Bromate results of bottled water samples in this study showed low variation as most of bottled water samples had Bromate less than 10 μ g/L (Table 2). The Bromate in bottled samples is within the Saudi standard limit for bottled water (< 10 μ g/L, Table 3, SASO, 2009).

The SO₄ concentrations are ranged from 13.48 to 61.62 mg/L (Table 1) with an average of 30.34 mg/L and in all the water samples the SO₄ concentrations are within the range of Saudi standards SASO (2009) for bottled

drinking water (150 mg/L, Table 3). This sulphate ion is generally harmless, except its effect on taste. The major physiological effects resulting from the ingestion of large quantities of sulphate are catharsis, dehydration and gastrointestinal irritation (Ghrefat, 2013).

Concentrations of NO₃ in the investigated water bottles vary from 0 to 22.66 mg/L (Table 2) with an average value of 2.47 mg/L. Concentrations of this nitrate ion in the bottled water samples are below the Saudi Arabian (SASO, 2009) recommended values for bottled drinking water (50 mg/L, Table 3). Fe concentration varies between 1.24 to 14.61 mg/L (Table 2) in the studied brands. All brands exceed the 0.3 mg/L level recommended by SASO (2009) standards as illustrated in Table (3).

3.1.1. Correlation analysis

Pearson's correlation coefficients among the contents of different ions are presented in Table (4). The Ca-Mg ($r = 0.421$) and Na-K ($r = 0.717$) pairs are positively correlated with each other significantly at the 95% confidence level, which may suggest a common source or a similar geochemical behavior for these metals as mentioned by Ghrefat (2013). However, negative and inverse correlations between metals indicate that these metals are derived from different sources (Ghrefat, 2013).

Table (4). Pearson's correlation coefficients between major ions in bottled drinking water brands (n = 16).

	Cl	SO ₄	Ca	Mg	Na	K	NO ₃	Fe
Cl	1							
SO ₄	-0.153	1						
Ca	0.653	-0.279	1					
Mg	0.789	0.259	0.421	1				
Na	0.428	0.337	0.117	0.481	1			
K	0.172	0.662	0.254	0.468	0.717	1		
NO ₃	0.741	0.015	0.434	0.873	0.625	0.421	1	
Fe	0.851	0.045	0.552	0.949	0.561	0.442	0.935	1

Conclusion

On the bases of results of this research study, the following conclusions could be derived:

- Most of the concentration levels of various physicochemical parameters in the studied bottled water types did not exceeded the international guidelines for drinking water.
- Variations of physicochemical properties were found between the bottled water brands.

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