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# Evaluation of microbial and physico-chemical quality of bottled water produced in Hamadan province of Iran

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**ABSTRACT**

**Introduction:** The increasing of population and limited drinking water resources has enhanced the necessity of using bottled water. Many people are now using bottled water because they believe it is a healthful alternative beverage to soft drinks or other bottled beverages. Therefore, the bottled water industry has grown immensely during the past decades. This descriptive cross-sectional study has investigated the quality of bottled water in market and factories of Hamadan province, Iran.

**Materials and methods:** In total, 33 bottled water samples produced in the Hamadan province of Iran, were randomly collected in 2012. The evaluated parameters were nitrate, nitrite, turbidity, $Na^+$, $K^+$, pH, total coliforms and fecal coliforms. The data were analyzed by SPSS software.

**Results:** All the samples meet standard regulations of national standards of Iran and the WHO guidelines. None of the samples, had coliforms or fecal coliforms. The mean values of nitrate, nitrite, turbidity, $Na^+$, $K^+$ and pH parameters were 8.34 mg/l, 0.024 mg/l, 0.38 NTU, 9.36 mg/l, 0.36 mg/l and 8.34, respectively.

**Conclusion**: We found that all measured parameters of bottled water in Hamadan province were within acceptable rang of the national and international standards, and consuming this kind of drinking water would not present any risk to the consumers' health.

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## Introduction

Water is the most abundant liquid on the earth's surface. About 97% of earth's water is salty water and only 3% is fresh water. Although fresh water is a renewable source, but most of the world's fresh water supply is ground water. This precious element is needed for the basic survival of all living organisms (Crittenden et al., 2012). With the global population ever increasing, the need for water has become a global concern. Nowadays, the production of enough drinking water is a major need. Many human diseases are related to lack of safe and hygienic water. Today, it is estimated that about 450 million people in 29 countries suffer from water shortages (Guler, 2007).

Due to the increasing demand for access to safe drinking water, the global population has turned to the use of bottled water. It is stated that over 89 billion liters of bottle water are annually used worldwide (Guler, 2007; Salvato, 2003). The United States and European countries bottled water market accounts for over 35% of the market. Approximately 13 billion liters are consumed in the USA who regrouped the highest bottled water drinkers on the planet in terms of sheer volume alone. The supply and demand theory, in this case bottled water, has necessitated a growing need for various water sources to manufacturing this product, and in some cases has virtually replaced the public water supply (Leivadara et al., 2008; Zazouli et al., 2013).

Today, consumer awareness has grown immeasurably as well as the idea of living a healthier life-style. People are thus choosing bottled water over tap water because it is perceived to be safer and of higher quality than tap water, which has become

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the global notion. Many people are now using bottled water because they view it as a healthful alternative beverage to soft drinks or other bottled beverages. Therefore, the bottled water industry has grown immensely in past decades. Bottled spring/ mineral water products are estimated to be about 4 million gallons per year in the USA (Guler, 2007; Leivadara et al, 2008; Salvato, 2003; Yekdeli-Kermanshahi et al., 2010). Worldwide, there are thousands of companies bottling water. It was estimated that people around the world drink approximately $131\times 10^9$ liters of bottled water each year; and half of this belongs to Western Europe (Versari et al., 2002). Also, the popularity of non-carbonated bottled water is generally higher than the carbonated bottled water (Guler, 2007).

Drinking water should be free of all pathogenic microorganisms. Water pollution, particularly the presence of pathogenic organisms may be one of the main sources of infectious and intestinal diseases. Today fecal coliforms found in water tables have been identified as the main pollutants (Williams, 2001), in addition to fertilizers and nitrogen residues in the soil. Various forms of nitrogen in soil are converted to nitrate by bacteria. Moreover, nitrates easily seep into the ground by passing through soil layers; reaching plant roots by the rain and eventually into the groundwater.

The presence of nitrate or nitrite in the water is often an indicator of contamination by fecal matter or wastewater and is a primary risk of nitrate in the drinking water. This occurs by the biological ingestion of nitrate, which is transformed to nitrite in the digestive system (Binghui et al., 2006; Rosenberg, 2003; WHO, 2004). The nitrite oxidizes iron in the hemoglobin of red blood cells; and ultimately destroys the red blood cells ability to create oxygen. In the absence of oxygen, body cells become disabled and skin is bruised. Moreover, nitrite can react with secondary and tertiary amines and produce nitrosamine which are carcinogens (Kellman and Hillaire-Marcel, 2003; Kiso et al., 2006).

Controlling bottled water available in the markets is useful in promoting public awareness and control systems. The purpose of this study was to evaluate the quality of bottled water widely used in the market and factories from Hamadan province of Iran.

## Materials and methods

This cross - sectional study was carried out on 11 most popular brands of bottled water produced in the Hamadan province of Iran. In total, three samples from each brand (33 samples) were randomly collected in 2012. The collected samples were transferred to laboratory and refrigerated at standard conditions (at 4 °C).

Physico-chemical and microbial tests was performed in accordance with standard methods. The total coliforms and fecal coliforms counts were performed based on Standard No. 3759 of Iran Standard and Industrial Research Institute (ISIRI, 2001). Next, the nitrate anion and nitrite anion were measured by a spectrophotometer DR-5000 (Hach Long/USA) at wavelengths of 500 nm and 507 nm, respectively. The pH level was determined by the potentiometric method with a pH meter (Metrohm/Switzerland). Total dissolved solids (TDS) were measured using TDS meter WTW machine (Germany). The measurement of sodium and potassium cations was accomplished by Ion Chromatography device (Metrohm/Switzerland). The turbidity level was measured by the Hach turbidity meter device (USA). To ensure sample testing accuracy in each measurement according to the mentioned parameters, each parameter was carried out in triplicate and the mean of each parameter was calculated.

The values of each parameter were compared to standard regulations of bottled waters (EPA, 2006; ISIRI, 2009).

The data were analyzed by SPSS software, V.16.0 (Mean ± SD). *P* value less than 0.01 was considered as significant.

## Results

According to Table 1, the results demonstrated that all the samples meet standard regulations of national standards of Iran and the WHO guidelines. None of the samples, had coliforms nor fecal coliforms (<1cfu/100ml).

Among examined brands, the highest and lowest mean value of nitrate were related to brands of *g* (24.63 mg/l) and *J* (0.88 mg/l), respectively; and were *B* (0.03 mg/l) and *C* (0.0079 mg/l), respectively for nitrite.

Also, a significant difference was observed ($p<0.01$) in nitrate and nitrite levels among different brands, but they were ranging into acceptable level.

The mean value of the sodium cation in the *J* brand was the highest with 21 mg/l; whereas *F*, *C* and *D* brands had the lowest values (2 mg/l). Also, among the different measured brands, *I* and *D* brands had the highest (0.7 mg/l) and lowest (0.1 mg/l) level of potassium cation, respectively.

Statistical analysis showed significant difference ($p<0.01$) between mean values of these two cations and all of them were in accordance to the standard level. The level of total dissolved solids (TDS) and turbidity parameters were below the acceptable limit (Table 1).

## Discussion

In this research, microbial and physico-chemical analysis of different parameters of the bottled waters samples were in accordance with standard regulations.

According to a survey on the thirteen bottled water companies in Kerman, Iran, all the samples had no microbial infection which is in accordance with our result (Loloei and Zolala, 2011).

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**Table 1:** Physico-chemical parameters of commercial bottled water in Hamadan province of Iran

| | pH | $K^+$ (mg/l) | $Na^+$ (mg/l) | Turbidity (NTU) | Nitrite (mg/l) | Nitrate (mg/l) | TDS (mg/l) |
|---|---|---|---|---|---|---|---|
| **Brands** | | | | | | | |
| *A* | 7.78±0.1 | 0.3±0.002 | 12±0.5 | 0.38±0.01 | 0.008±0.002 | 3.473±0.2 | 214.6±0.5 |
| *B* | 7.57±0.2 | 0.2±0.002 | 14±0.3 | 0.4±0.01 | 0.03±0.001 | 6.6±0.22 | 269±0.3 |
| *C* | 8±0.15 | 0.1±0.002 | 2±0.1 | 0.58±0.02 | 0.0079±0.001 | 5.87±0.54 | 120±0.25 |
| *D* | 8±0.15 | 0.1±0.002 | 2±0.1 | 0.35±0.01 | 0.02±0.001 | 9.240.35 | 85±0.6 |
| *E* | 7.94±0.1 | 0.4±0.003 | 8±0.3 | 0.4±0.02 | 0.019±0.001 | 10.25±0.4 | 171.6±0.7 |
| *F* | 7.83±0.2 | 0.4±0.003 | 2±0.1 | 0.32±0.01 | 0.0137±0.002 | 2.78±0.6 | 48.3±0.5 |
| *G* | 8 ±0.15 | 0.2±0.002 | 4±0.2 | 0.39±0.01 | 0.0137±0.001 | 24.63±0.4 | 170±0.30 |
| *H* | 7.51±0.2 | 0.6±0.005 | 10±0.3 | 0.3±0.02 | 0.02±0.001 | 6.6±0.5 | 123±0.4 |
| *I* | 7.82±0.1 | 0.7±0.004 | 16±0.3 | 0.35±0.02 | 0.014±0.001 | 4.54±0.76 | 265±0.3 |
| *J* | 7.92±0.2 | 0.5±0.004 | 21±0.5 | 0.35±0.01 | 0.022±0.001 | 0.88±0.15 | 355±0.6 |
| *K* | 7.95±0.1 | 0.4±0.002 | 12±0.3 | 0.38±0.01 | 0.0148±0.001 | 16.86±0.4 | 205±0.15 |
| **Acceptable level** | 6.5-8.5 | NSA* | 200 | 5 | 3 | 50 | 1000 |

* No Standard Available

Similar findings were found by Miranzadeh et al. (2011a) and Godini et al. (2011) and Miranzadeh et al. (2011b) in Ardabil, Ilam and Kashan, Iran. This situation indicates that the methods applied by the companies for disinfection, such as UV irradiation, are useful and practical. However, according to Venieri et al. (2006), *Pseudomonas aeruginosa*, a food-borne bacterium, were found among 1527 bottled water samples in Greece. The study by Franco and Cantusio (2002) in Brazil demonstrated the presence of *Cryptosporidium spp.* in three types of bottled water samples.

In a similar investigation, 23% and 46% samples of Kerman were above the standard limits regarding potassium and sodium, respectively (Loloei and Zolala, 2011). The high amount of these minerals is of matter of health concern. Because the elevated potassium level in bottled water can be a cause of renal disorders and sodium plays a role in developing high blood pressure (EPA, 2006).

Evaluation of nitrate and nitrite anions in this study showed that their total mean values in all samples were below the standard limits. The results of this study were in agreement with the study by Jahed-Khaniki et al. (2008) conducted in Tehran, and Godini et al. (2011) in Ilam, Iran. Another investigation on nitrate level of bottled and natural mineral water in Iran demonstrated that nitrate concentrations in natural mineral waters were between 0-15 mg/l with a mean of 5.37 mg/l. The according level in packaged waters was between 0-25 mg/l with a mean of 6.47 mg/l (Norbakhsk et al., 2008).

In this study, pH and TDS levels in the samples were in optimal standard limits. A 1999 study on bottled water in Kuwait showed that about 44% of the samples had pH values higher than 8 and 8% of them were slightly acidic (Alfraji et al., 1999).

## Conclusion

In conclusion, we found that all measured parameters of bottled water in Hamadan province were within acceptable rang of the national and international standards, and consuming this kind of drinking water would not present any risk to the consumers' health. In the future, more investigations of produced bottled water in other parts of Iran, especially from regions which may present a high risk, is recommended.

## Conflicts of interest

The authors had no conflict of interest.

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