

COMPLIANCE OF THE LABEL AND THE QUALITY OF TABLE AND MINERAL COMMERCIAL BOTTLED DRINKING WATER

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EXTENDED ABSTRACT

Ten brands of commercial bottled water consisting of six mineral and four table types were collected randomly from local supermarkets in Hania, Crete, and assessed for the compliance between the label of the bottle and the quality of the water. Water quality constituents analyzed include pH, conductivity, total hardness, total solids, chloride, sulphate, nitrate, chlorine, total coliforms, *Escherichia coli*, *Enterococcus fecalis* and aerobic bacteria. Official methods were employed for the analysis of the qualitative parameters.

The measured pH values of all the bottled water brands varied between 7.5 and 8.2 which are within the legislation limits. Conductivity label values referred between 390 and 1558 μ S/cm for the natural mineral waters, and from 255 to 410 μ S/cm for the table waters. All samples of both mineral (except the brand MW6) and table water brands showed very low conductivity compared with the recommended guidelines and always within the limits of the label values. The measured values of total hardness and total solids were very close to the label values for both the mineral and table water samples. All samples of the bottled water brands contained less than 35mg/l of chloride, values far below the legislation limit of 250mg/l and in accordance with the label values. Brands named TW1 and MW1 showed the higher measured chloride concentrations of 21 and 33mg/l respectively, although lower than the label values. Sulphate concentrations measured in all samples were close to the label values, except the TW2 samples where the measured value of 4.8mg/l exceeds the label value of 3mg/l. In the majority of the samples of bottled water brands, sulphate concentration was below the legislation limit of 250mg/l. However, in the MW6 samples the measured value of 1140mg/l exceeds 4.5 times the legislation limit for sulphate concentration. None of the water samples that were analyzed showed any significant level of nitrate ions and measured values were below of those written on the label. The null findings of the bacteriological indicators such as total coliforms, *E. coli* and *Enterococcus fecalis* demonstrated the absence of fecal contamination in all the samples of the bottled water brands.

The present study has demonstrated that all the measured values of the water quality constituents in the bottled water brands analyzed were in compliance with the label values and in most of the brands within the national legislation acceptable limits. Towards the assurance of the high quality of the tested brands, additional measures should be taken in order to control the presence of aerobic bacteria which are indicators of potential seasonal and long term changes in the general bacteriological quality of the source water.

Keywords: bottled water, water quality, label compliance.

1. INTRODUCTION

A growing concern on the bottled water quality has been recorded due to the significant increase in bottled water consumption over the last decade. Like any other food product, bottled water must be processed, packaged, shipped and store in a safe and sanitary manner and accurately labeled [4].

The sale and consumption of bottled water has increased both in Greece and in other parts of the world nowadays, as many consumers use it as a safer alternative to tap water. Within Greece, bottled water consumption has increased in the last few years because of local problems faced with potable water in certain areas and the seasonal demand from the tourists. It should be mentioned that bottled water consumption has increased from 13 to 45 liters per person per year, between the years 1989-2004.

Several studies on the quality of bottled water reported violation of some drinking water permissible limits. A comparable chemical evaluation of 25 samples of commercial bottled water from three cities in eastern Alabama showed that some samples had pH and electric conductivity values that exceed the EU and EPA standards. In addition, it was also concluded that treated bottled waters have less solids than the untreated bottled waters. In contrast, it was found that concentrations of Nitrate, Sulfate and Chloride anions were lower than the levels imposed by the EU [1]. By another study on the same subject, which was performed in samples of bottled water in Egypt, it was indicated that some Natural Mineral Water samples had higher conductivities and concentrations of Chloride anions than tap water. At the same time, it was demonstrated that Natural Mineral waters had very high concentrations in Nitrate anions [2].

In a corresponding study concerning the microbial quality of domestic and imported brands of bottled water in Trinidad (West India), 18 of the domestic brands - from the 344 samples – were found positive when checked for total coliforms presence and 5 of all samples were found positive to *E. coli* testing. Moreover, in some of the 344 samples, colonies of *Enterococcus faecalis* were occasionally detected whereas the numbers of aerobic bacteria colonies were low ($3.6 \times 10^3 \pm 1,8 \times 10^4$).^[3] In a Canadian study screening the bottled water for the presence of indicator and pathogenic bacteria, it was found that 3.7% of the samples checked had total coliforms. Furthermore, it was indicated that in the 23.3% and 5.5% of the 3460 samples checked, more than 100 colonies of aerobic bacteria per ml of sample and more than 10^4 colonies of aerobic bacteria per ml of sample were found respectively [4,5].

The aims of the present study were a) the comparison of the water quality constituents across the bottled water brands, b) the experimental verification of the parameters values inscribed on the labels of the different bottled water brands and c) the determination of the microbial quality of commonly available brands of bottled water in Hania-Crete.

2. MATERIALS AND METHODS

This work was elaborated in the Laboratory of Water and Soil Quality Control, TEI Crete, Branch of Hania. The sampling period was from August to December 2004 with twenty days intervals.

Six brands of mineral waters and four brands of table waters were bought from three selling points of the same supermarket chain, in the area of Hania. All the brand names have been replaced with code names and a randomly chosen number in order to avoid

any commercial consequences. The mineral waters were coded MW1, MW2, MW3, MW4, MW5, MW6 and the table waters TW1, TW2, TW3, TW4, TW5.

Official methods were employed for the analysis of the qualitative parameters pH, electric conductivity (EC), total hardness, chloride, nitrate, sulfate, free chlorine and total solids [6,7].

A volume of 100 ml of each water sample was filtered through sterile 47 mm/0.45 pore size cellulose filters (Pall-Gelman Sciences GN 66191) which, then, were placed on Membrane Lauryl Sulfate Broth substrate (Lab 082-LAB M) into petri dishes [8]. After 24 hours of incubation at 37°C and 44°C for total coliforms and *E. coli*, respectively, the developed colonies were counted. As far as it concerns the detection of *Enterococcus faecalis*, all water samples were filtered, through the aforementioned filters, and were then placed on Slanetz and Bartley Agar nutrient substrate (LabM 166 - LAB M) into petri dishes [8]. The colonies which appeared after 48 hrs of incubation at 35°C, were counted. For the detection of aerobic bacteria, a volume of 9 ml of the nutrient substrate Water Plate Count Agar (Lab 197) was inoculated with 1 ml of each water sample into petri dishes and incubated at 22°C for 68 hours. The colonies of the aerobic bacteria, which grow at 22°C, were counted and expressed as cfu/ml of sample. Following the same procedure, inoculated petri dishes were incubated at 37°C for 44 hours. The colonies of the aerobic bacteria, which grow at 37°C were counted and expressed as cfu/ml of sample [8].

3. RESULTS AND DISCUSSION

The bottled water physicochemical and chemical characteristics were compared with the respective label values which are in accordance with the EU and the national drinking water standards. The results of the quality characteristics of the brands of bottled water studied are shown in Figure 1.

The measured pH values of all the bottled water brands varied between 7.5 and 8.2 which are within the legislation limits (6.5-9.5). However, most of the mineral waters showed lower pHs compared to table waters (Figure 1A). Conductivity label values referred between 390 and 2250 μ S/cm for the natural mineral waters, and from 255 to 410 μ S/cm for the table waters. All samples of both mineral (except the brand MW6) and table water brands showed very low conductivity compared with the recommended guidelines and always within the limits of the label values. The 2225 μ S/cm conductivity measured in the MW6 samples was close to the upper limit (2500 μ S/cm) of the EU standards (Figure 1B).

The measured values of total hardness (Figure 1C) and total solids (Figure 1D), were very close to the label values for both the mineral and table water samples.

All samples of the bottled water brands contained less than 35mg/l of chloride, values far below the legislation limit of 250mg/l and in accordance with the label values. Brands named TW1 and MW1 showed the higher measured chloride concentrations of 21 and 33mg/l respectively, although lower than the label values (Figure 1E).

Although indications of free chlorine presence in the samples were recorded, data are not presented since the analytical procedure showed unacceptable accuracy in the low measuring area <0.1mg/l.

Sulphate concentrations measured in all samples were close to the label values, except the TW2 samples where the measured value of 4.8mg/l exceeds the label value of 3mg/l. In the majority of the samples of bottled water brands, sulphate concentration was below

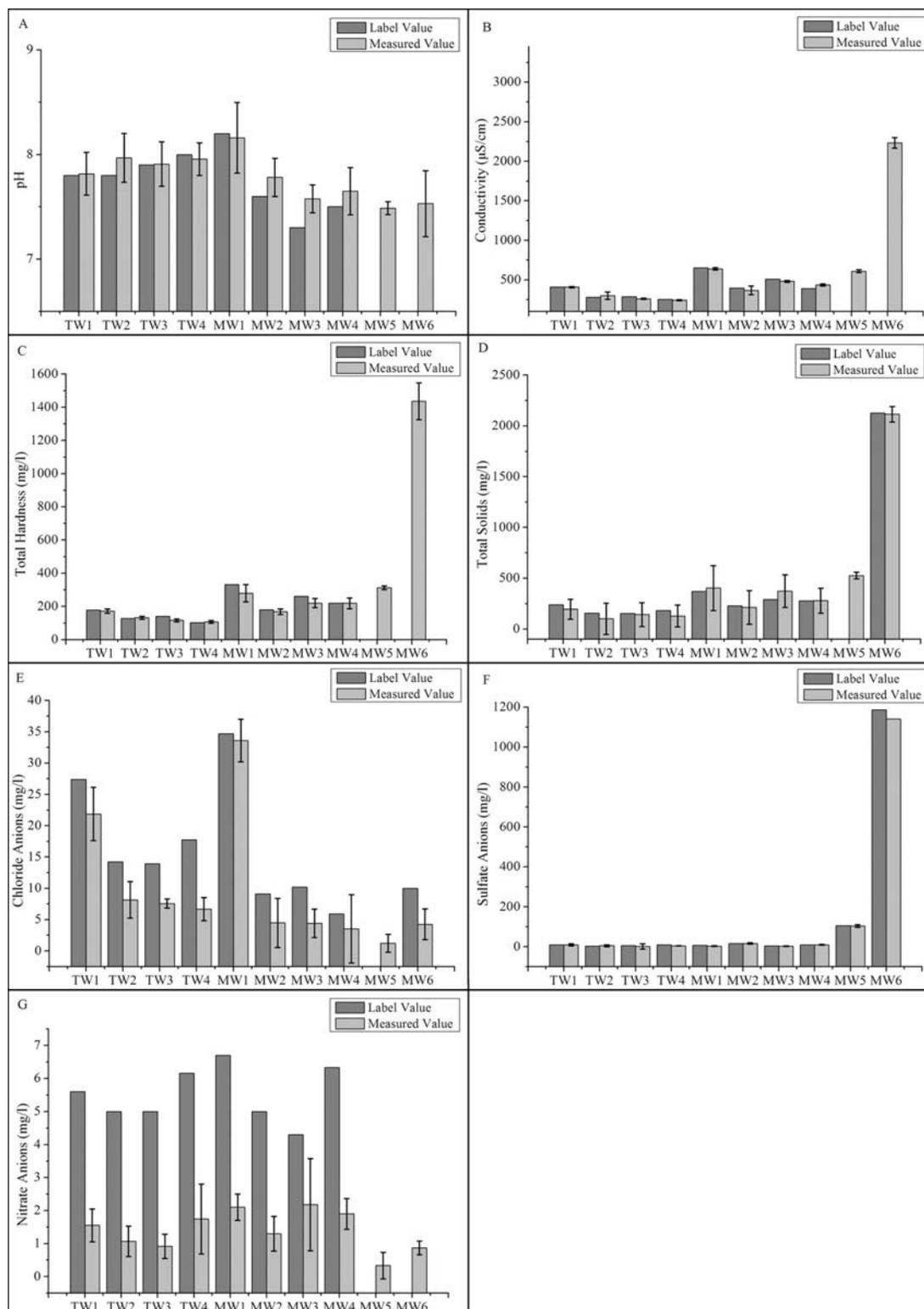


Figure 1: Label values (dark grey bars), averages of the measured values (light grey bars) and standard deviations (black lines) of all the physicochemical parameters for each sample. A) pH, B) Conductivity, C) Total Hardness, D) Total Solids, E) Chloride Anions, F) Sulfate Anions and G) Nitrate anions. (TW stands for Table Water and MW for natural Mineral Water).

the legislation limit of 250mg/l. However, in the MW6 samples the measured value of 1140mg/l, exceeds 4.5 times the legislation limit for sulphate concentration (Figure 1F). None of the water samples that were analyzed showed any significant level of nitrate ions and measured values were below of those written on the label (Figure 1G). The legislation limit for nitrate ions in drinking water is 50mg/l.

The null findings of the microbiological analysis of bacteriological indicators such as total coliforms, *E. coli* and *Enterococcus faecalis* demonstrated the absence of fecal contamination in all the samples of the bottled water brands.

However, Table 1 presents the number of samples of each bottled water brand in which aerobic bacteria colonies (Heterotrophic bacteria), in both 37°C and 22°C, exceeded the national legislation limits (less than 100 colonies/ml of sample in both 37°C and 22°C). It was found that all the bottled water brand, except MW2, slightly exceeded the limits at least once, while only samples of the bottled water named TW3 and MW3 showed colony counts far above the legislation limits.

4. CONCLUSIONS

The present study has demonstrated that all the measured values of the water quality constituents in the bottled water brands analyzed were in compliance with the label values and in most of the brands within the national legislation acceptable limits. Towards the assurance of the high quality of the tested brands, additional measures should be taken in order to control the presence of aerobic bacteria which are indicators of potential seasonal and long term changes in the general bacteriological quality of the source water [9].

Table 1: Number of samples containing aerobic bacteria above the legislation limits of each bottled water brand. TW stands for Table Water and MW for natural Mineral Water.

Various Samples	Colonies at 37 °C	Colonies at 22 °C
TW1	1/6	1/6
TW2	2/6	2/6
TW3	4/6	5/6
TW4	1/6	1/6
MW1	2/5	2/5
MW2	0/5	0/5
MW3	3/5	5/5
MW4	1/5	1/5
MW5	1/3	1/3
MW6	1/6	1/3

REFERENCES

- Ikem A, Oduyungbo S, Egiebor N.O., Nyavor K. (2002): Chemical quality of bottled water from three cities in eastern Alabama. *Sci. Total Environ.* 285, 165-175.
- Saleh M.A., Ewane E., Jones J., Wilson B.L. (2001): Chemical Evaluation of Commercial Bottled Drinking Water from Egypt. *J. Food Composition and Analysis* 14, 127-152.

3. Bharath J., Mosodeen M., Motilal S., Sandy S., Sharma S., Tessaro T., Thomas K., Umamaheswaran M., Simeon D., Adesiyun A.A. (2003): Microbiological quality of domestic and imported brands of bottled water in Trinidad. *Int. J. Food Microbiol.* 81, 53-62.
4. Warburton D.W. (2000): Methodology for screening bottled water for the presence of indicator and pathogenic bacteria. *Food Microbiol.* 17, 3-12.
5. Warburton D., Harrison B., Crawford C., Foster R., Fox C., Gour L., Krol P. (1998): A further review of microbiological quality of bottled water sold in Canada: 1992-1997 survey results. *Int. J. Food Microbiol.* 39, 221-226.
6. MERCK . 2004. *Operation Manual*
7. APHA (1995) '*Standard methods: for the examination of water and wastewater*'. Published jointly by: American Public Health Association, American Water Works Association, Water Environment Federation, 19th Edition, Washington DC.
8. LAB M. 2002. *The Microbiology Manual*. IDGroup.
9. US EPA. 2002. *The Microbiology of Drinking Water. Part 1. Water Quality and Public Health, Methods for the Examination of Waters and Associated Materials*. pp10-16.