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Physicochemical and Microbiological Assessment of Bottled Water in Al-Kut, Iraq

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Abstract

Bottled water is a key alternative of tap water with great attention over past decades due to the direct link with human health. Twelve bottled water brands available in Kut markets were collected during the winter season of 2022. Tests included physical properties color, taste, and odor. Besides chemical properties pH, total dissolved solids (TDS), and microbial analyses by using standard culture media. Iraqi standard specifications were used as a basis for evaluation in addition to a comparison between test results and the package. Physical tests indicated that all bottled water samples were acceptable in terms of taste and smell, according to specifications. Most microbial test results complied with the Iraqi standards and WHO guidelines except for type D which recorded the presence of coliform bacteria. Chemical results showed pH values tended toward acidity and do not always match samples label and do not complying with the Iraqi standards. While total dissolved salts and turbidity values varied among samples most complied with the standard specifications.

Keywords: Bottled water, Microbiological, TDS and Iraqi standard specifications.

1. Introduction

Bottled water is defined as water prepared for human consumption and packaging in bottles, plastics, cans, and sometimes as ice ready to use [1, 2]. The bottled water industry has recorded astronomical growth over the past five decades [3].

It has become popular due to many reasons among which are increasing population, rising incomes, the complaint about the quality of tap water, influence of marketing campaigns and a trend of

consumers toward healthy lifestyles [4]. Bottled water as drinking water source is common in most countries worldwide [5]. The number of bottled water factories in Iraq is increasing to higher consumer demand. Apart from the general perception among consumers that bottled water is pure and safe. Studies have revealed that some products exceed the microbiological and chemical limits imposed by national and international standards [7].

The World Health Organization (WHO) 2003 guidelines state that drinking water should meet the physical, chemical, and microbiological standards acknowledged internationally [8]. Properties giving aesthetic qualities to water include alkalinity, hardness, chloride, and total dissolved solids. TDS is used in measuring inorganic salts content together with small amounts of organic matter present in a solution. Contaminated drinking water is estimated to be 502000 deaths annually. Clean water and improved health conditions could prevent 9.1% diseases and 6.3% deaths globally-as per statistics- all other considerations remain constant [9].

All bottled water products shall comply with the FDA's quality standards, labeling regulations, and Good Manufacturing Practices [10]. Results of studies done in Saudi Arabia, Iran, Iraq, Malaysia, and Kuwait about the quality levels of bottled water showed differences between declared values and measured values as well as organic contaminants found in some samples [11]. Therefore, the evaluation of bottled water in consideration of health standards which it must meet to be safe for human consumption becomes highly significant [12].

The current study aims at assessing the quality levels of bottled drinking water packed within Kut area and sold in local markets, by comparing test results with Iraqi standard specification as well as with values declared on packaging by producing company.

2. Material and Methods

Physical, chemical, and microbial properties of twelve brands of Iraqi bottled drinking water in Kut markets during the winter season 2022 were tested. Examined samples of bottled water were with a capacity of 200 mL perfect and tightly sealed. The Iraqi standard specifications for bottled drinking water issued by the National Center for Standardization and Metrology have been adopted as a local basis for assessing water quality in this study.

Limits of the studied variables were determined according to the relevant standard specifications. Color was determined by the visual comparison method. Taste and odor were determined organoleptically under physical examinations. For microbial analyses, the culture method in Petri dishes was applied using such media as Nutrient Agar, MacConkey Agar, Methyl Red-Vogess ProSkauer, and Pseudomyces Agar.

The incubation of plates at 37 and 45 °C for bacteria to grow. For chemical analysis, the pH was determined at room temperature using a Philips pH meter. Total dissolved solids (TDS) were measured by a conductivity meter which estimates the total salt content of water and records the temperature of water. Turbidity was measured with a turbidity meter and is expressed in nephelometric turbidity units (NTU).

3. Results

Physical tests provide results that show all bottled water samples give a good taste and odor. Hence acceptable to the approved specifications on sensory characteristics. The microbial test results of bottled water mostly contain elements falling well within the range prescribed by Iraqi standard specifications for drinking water and WHO guidelines on drinking water. Except in one sample of type D where coliform bacteria were found hence not meeting the above specifications in Table 1. Results found a higher number of free not-contaminated samples, 91.67% (11/12) as compared to not-free contaminated samples 8.33% (1/12) with statistical significance ($p < 0.0044$; 95 % CI; 479.5 to 579.50) as shown in table 1, table 2, and figure 1.

Table 1: Results of microbial tests and their comparison with Iraqi standard specifications.

Brand Code	Free from coliform bacteria and *P. aerugninosa*	Result
N		Confirmed
S		Confirmed
Z		Confirmed
L		Confirmed
S1		Confirmed
A		Confirmed
B		Confirmed
Y		Confirmed
M		Confirmed
D		Not Confirmed
N1		Confirmed
B		Confirmed

Table 2: Overall results of microbial tests and their comparison with Iraqi standard specifications.

Result	Number	%
Free	11	91.67 **
Not free	1	8.33
***p*-value**	0.0044	
95% CI	479.5 to 579.5	

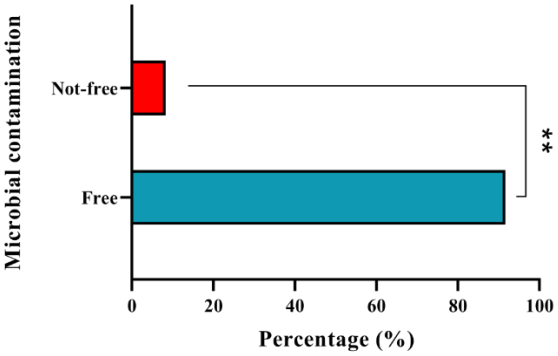

Figure 1: Bacterial tests and their comparison results with Iraqi standard specifications. Significance * ($p < 0.01$), ** ($p < 0.001$).

Resulted pH values, as shown in table 3, slightly deviate from the acidic side and do not totally conform to the values stated on the package. A very significantly lower PH value ($p < 0.0005$; 95% CI: 0.5908 to 13.87), was observed in study samples (6.07 ± 0.116) compared to the registered values (7.208 ± 0.04) as shown in figure 2.

It was observed that values of all dissolved salts were lower than those indicated on the package, except for sample B which was higher. With respect to TDS, values have significantly declined ($p < 0.0021$; 95% Cl: 478.7 to 631.9) in study samples (41.25 ± 12.08) compared to registered values (120.33 ± 3.71) as demonstrated in figure 3. The turbidity was not consistent except for water brands N, A, B and D. However, a significantly reduced ($p < 0.0139$; 95% Cl: 0.1947 to 0.3517) mean study sample values of (0.057 ± 0.011) compared to the registered samples with means of (0.1 ± 0) in figure 4.

Table 3: Comparing laboratory results of some chemical properties of bottled water types with the data written on the package.

Brand code	Test					
	PH		TDS		Turbidity	
	Study samples	Registered on the package	Study samples	Registered on the package	Study samples	Registered on the package
N	6.27	7.3	93	125	0.1	0.1
S	6.5	7.3	102	125	0.02	0.1
Z	5.55	7.1	16	125	0.01	0.1
L	6.18	7.3	20	124	0.01	0.1
S1	6.1	7.2	32	125	0.06	0.1
A	5.71	6.9	9	120	0.1	0.1
B	5.69	7.3	8	125	0.1	0.1
Y	5.92	7.1	22	120	0.05	0.1
M	6	7.4	31	80	0.07	0.1
D	5.7	7.1	3	125	0.1	0.1
N1	6.26	7.2	31	125	0.05	0.1
B	6.96	7.3	128	125	0.01	0.1
Mean	6.07	7.208	41.25	120.33	0.057	0.1
± SE	0.116	0.04	12.08	3.71	0.011	0
p-value	0.0005		0.0021		0.0139	
95% CI	0.5908 to 13.87		478.7 to 631.9		0.1947 to 0.3517	

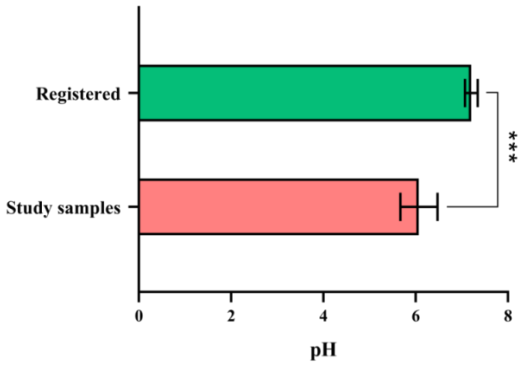

Figure 2: Results of PH tests and their comparison with the data written on the package; significance ($p < 0.01$) *, ($p < 0.001$) **.

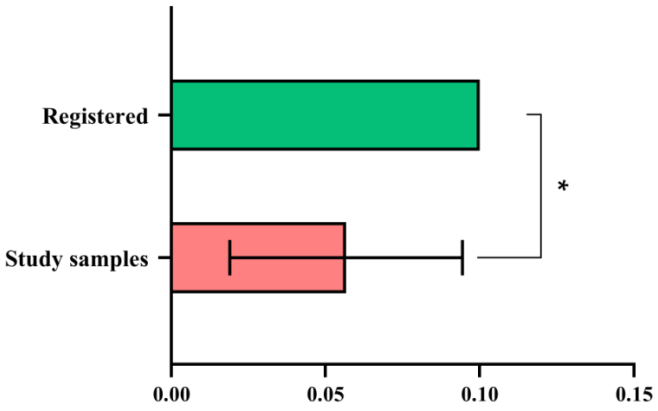

Figure 4: Results of Turbidity tests and their comparison with the data written on the package; significance ($p < 0.01$) *, ($p < 0.001$) **.

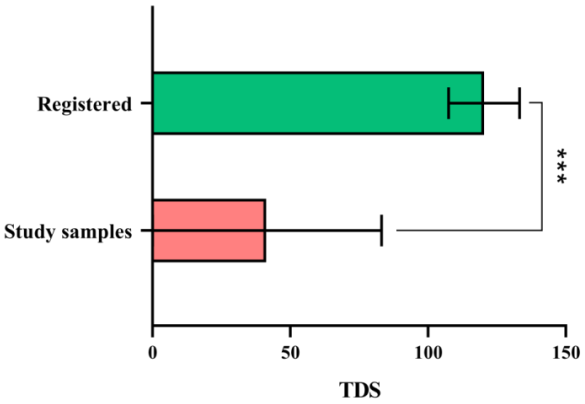

Figure 3: Results of TDS tests and their comparison with the data written on the package; significance ($p < 0.01$) *, ($p < 0.001$) **.

pH results presented in table 4 show that most values do not fall within the Iraqi standard specifications for drinking water, except S and B which were within permissible limits. On the other hand, it was found that the values of total dissolved salts (TDS) and turbidity for all samples conform with the Iraqi standard specifications for drinking water. In comparative values among the study samples, the higher pH was detected in N1 (6.26) and lower in Z (5.55).

For TDS, a higher value was reported in B (128) and lower recorded in D (3). Significant turbidity increases were noticed in N, A, B and D (0.1). Significant decreases appeared in Z, L and B (0.01) as well as S (0.02) and Y (0.05) as shown in table 4.

Table 4: Comparison of laboratory results of some chemical properties of bottled water types with Iraqi standard specifications.

Brand code	PH Test result	TDS Test result	Turbidity Test result
N	6.27	93	0.1 ***
S	6.5	102	0.02
Z	5.55	16	0.01
L	6.18	20	0.01
S1	6.1	32	0.06
A	5.71	9	0.1 ***
B	5.69	8	0.1 ***
Y	5.92	22	0.05
M	6	31	0.07
D	5.7	3	0.1 ***
N1	6.26	31	0.05
B	6.96 ****	128 **	0.01
M ± SE	6.070 ± 0.116	41.25 ± 12.08	0.0567 ± 0.0108
p-value	0.0001	0.0058	0.0003
95% CI	5.815 to 6.325	14.66 to 67.84	0.03269 to 0.08064

4. Statistical Analysis

Significant differences between values in the current study were detected using the T-test and One-Way ANOVA in GraphPad prism software version 8.0.1 at $p < 0.05$ (*), $p < 0.01$(**), $p < 0.001$(***), and $p < 0.0001$(****). Values are expressed either as mean ± standard error (M ± SE) or as number (percentage) [No. (%)].

5. Discussion

Drinking water is a basic human requirement, and specific quality standards also normally characterize the use [4]. Consumption of bottled water in the world has registered as one of the highest growths among all other consumable products because people perceive a high level of quality associated with it relative to tap water [13]. Also, developed and developing countries massively consume bottled water [14].

Results obtained from the current study will evaluate standard specifications bottled waters are safe for consumer health. Results of physical tests showed that all bottled water samples were acceptable in terms of taste and odor, indicating their compliance with the approved sensory standards for drinking water. These findings support what has been recommended by health organizations that emphasize taste and odor as key determinants of consumer acceptance and water which lacks sensory acceptability may drive consumers to seek alternative sources even if these are less safe or more expensive [15-16].

The link between microbial contamination of water and bad hygiene practices during production or storage is common. Microbial tests showed that most

bottled water brands conformed to Iraqi Fecal contamination and failures in sterilization or delivery. This is also like previous reports on the levels of coliform and heterotrophic bacteria in bottled water above both national and international guidelines [2]. Clean water is essential for good health and reduces the transmission of pathogenic microorganisms [17].

According to WHO (2017), the presence of any coliform bacteria in a sample volume test of drinking water clearly indicates fecal contamination and therefore warrants an immediate rejection response towards that sample [18]. Semerjian reported that microbial pollution in bottled waters could possibly indicate the presence or absence relationship between pathogenic enteric microbes such as *Salmonella spp*., *Shigella spp*. and *Vibrio cholerae* with actual fecal pollution [2,13].

With regards to the pH, a health guideline value is normally not specifically assigned due to its limited direct effects. However, consumption of acidic water has consequences in tissues damage [17]. In this study, the pH values (5.55-6.96) tend towards acidity and do not match either the package labeling or comply with Iraqi drinking water standards except for samples S, and B. The low pH may be because of dissolved carbon dioxide which increases acidity as well as chlorination during treatment which can further lower the pH [19-20]. The chemical test results for total dissolved solids (TDS) and turbidity in the bottled water samples do not exactly match what is labeled but remain within the permissible limits of Iraqi standard specifications for drinking water in 2009. This means that they comply with local requirements on purity and clarity, thus reflecting the effectiveness of treatment and purification processes applied by producing companies [21].

Low levels also indicate positivity towards effective treatments applied. High TDS levels may have health effects, an association between high TDS cardiovascular particularly women during pregnancy have been reported where toxemia was connected to excessive TDS in drinking water [22]. Our result concerning Saleh's report about Kut city's water filtration plants' output agrees completely except that he found a turbidity value higher than the Iraqi standard limit [23].

6. Conclusion

This study showed that most bottled water samples in Al-Kut city were compliant with Iraqi and WHO standards on the physical, chemical, and microbiological properties, with some variations. Type D contained coliform bacteria and values of pH, total dissolved solids, and turbidity varied among the samples as compared to labeling and standard specifications. It therefore calls for regular monitoring and adherence to proper standards to protect public health and enable consumers' safety.

7. References

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