

Assessment of Microbiological Quality, Knowledge and Practice on Domestic Bottled Water Brands in Malaysia

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ABSTRACT

Objective: The study was conducted to assess microbiological quality of 11 domestic bottled water brands in Malaysia. This study also presented university students' perceptions on domestic bottled water brands.

Method: A cross-sectional study was conducted to determine the total coliform, *Escherichia coli* and *Pseudomonas aeruginosa* using membrane filtration method. Questionnaire survey was distributed to 215 university students of Universiti Putra Malaysia to determine level of knowledge and attitude towards microbial quality in bottled water.

Result: The findings showed that *Escherichia coli* and *Pseudomonas aeruginosa* colonies were not detected in any of 11 brands of bottled water. Total coliform colonies were detected in two domestic bottled water brands originated from Taiping (Perak) and Lenggeng (Negeri Sembilan). A total of 42.8% of respondents were identified to have a good score (more than 80%) of knowledge level on microbial quality in domestic bottled water. A total of 29.8% of respondents have a good level of attitude (score more than 75%) and agreed that bottled water is cleaner than tap water without knowing that the bottled water can be contaminated with bacteria.

Conclusion: Our findings clearly raised the concerns regarding the microbiological quality of domestic bottled water brands and highlighted the danger posed to the public health. It is crucial to make sure the consumers are well informed and aware that the perception that bottled water is always safer than tap water can be misleading. Nevertheless, this study acts as a baseline study on microbiological quality, knowledge and practice on domestic bottled water brands in Malaysia.

Keywords: Bottled water, Malaysia, knowledge, attitude, microbiological quality

1. Introduction

There has been a steady increase in bottled water consumption worldwide (Aris et al. 2013; Drinking Water Research Foundation, 2011; Ward et al. 2009). Bottled water consumption in Asia has increased at an annual rate of 13% and has reached 135 billion liters in 2010 (Euromonitor International, 2013). Although latest data on bottled water is not available, bottled water consumption in Malaysia has raised 100 million litres from year 1998 to 2004 following the similar trend worldwide (World Water Data, 2011). Growth of the bottled water market in Malaysia is fuelled

by the following factors such as convenience and portability of bottled water, taste, safety, healthiness, disillusionment towards municipal water, environmental concerns and paradigm shift towards healthy beverages (Azrina et al. 2012; Hall and Stagg, 2012; Frost and Sullivan, 2007).

Safety and quality of drinking water including bottled water is a crucial public health concern (Moniruzzaman et al. 2011; Liguori et al. 2010). Contamination in bottled water have been responsible factors for infectious diseases transmission which caused serious waterborne diseases (World Health Organization, 2011). Moreover according to Obiri-Danso et al. (2003), proliferation of bottled water demand has raised a concern on the hygienic production,

quality of water source, treatment method, packaging materials and improper handling and storage. Armas and Sutherland (1999) explained that bottled water has been a vehicle of transmission of waterborne disease outbreaks. Reported outbreaks were associated with the contamination of water source, malfunctions in equipment or devices used in the or distribution and the contamination introduced during bottling process (Blackburn et al. 2004). *Vibrio cholera* causing outbreak of cholera in Saipan (Marianas Islands) was associated with bottled water. Although a full epidemiological study on those who drank the water lacked in this incidence, The Centre for Disease Control and Prevention or CDC, (1995) reported four people were hospitalized in serious condition. Acute gastrointestinal illness due to microbiological quality was also reported in the United States due to contamination during shipping, hauling, or storage (CDC 1995) of bottled water. Medical News Today (2003) has reported 50,000 cases of food poisoning in Wales and England were associated with bottled mineral water as potential hazard with public health implications.

In Malaysia, although there was no reported outbreaks caused by bottled water, Malaysian Ministry of Health (2012) concluded that many waterborne diseases were frequently under-reported. Although outbreaks elsewhere worldwide have brought public attention to the fact that bottled water are capable are capable of the source of water- and food-borne diseases. However, not many in Malaysia are aware of this (Malaysian Ministry of Health 2012; Ward et al. 2009; Warburton, 1993). Therefore at present, there is inadequate information on consumer in terms of knowledge and practice on microbiological quality of bottled waters. Thus, it is important that consumers can be assured of bottled water quality and well informed in terms of knowledge and practice. To the best of our knowledge, very few studies have conducted to this end dealing with domestic bottled water in Malaysia. Azrina et al. (2012) have included bottled water samples to study the content of minerals of drinking water in Malaysia while Aris et al. (2013) and Saad et al. (1998) studies have focused on anions and cations in bottled water. Domestic bottled water brands were also studied on bisphenol A concentration (Santhi et al. 2012). Aini et al. (2007) has focused on Malaysian households' drinking water practices involving bottled waters. Although microbiological quality of bottled water information (knowledge and practice), literatures and reports are scattered worldwide, yet very few studies have been conducted in Malaysia.

Therefore, the objective of the present study was to investigate microbiological quality in domestic bottled water brands in Malaysia. Moreover, this study was also performed to examine the reasons for preferring bottled water as source of drinking water and establishing the level of

awareness on the safety of bottled water as drinking water source among Universiti Putra Malaysia students. Output of this study is essential as a baseline information on microbiological quality of domestic bottled water with the university students as the target group.

2. Materials and Method

2.1. Bottled water sampling

A total of 11 brands of commercially available bottled water consisting mineral and drinking waters were purchased randomly from various outlets in Selangor. The sampling was done in March 2012 and all the bottles were obtained in the same production year. All samples were in plastic container with plastic screw caps. Each brand was designated with A to K for privacy purpose. Table 1 presents the classification of the bottled waters in terms of brands, types, sources and volume.

Table 1: Classification of bottled water (MW=mineral water, DW=drinking water)

Brand	Type	Source	Volume
A	MW	Taiping, Perak	600 mL
B	MW	Taiping, Perak	600 mL
C	MW	Taiping, Perak	500 mL
D	MW	Lenggeng, Negeri Sembilan	600 mL
E	MW	Lenggeng, Negeri Sembilan	600 mL
G	MW	Johor	600 mL
H	DW	Treatment water, SYABAS	600 mL
I	DW	Treatment water, SYABAS	600 mL
J	DW	Treatment water, SYABAS	600 mL
K	DW	Treatment water, SYABAS	600 mL

2.2 Microbiological Analysis

Total coliform, *Escherichia coli* (*E.coli*) and *Pseudomonas aeruginosa* (*P. aeruginosa*) were enumerated by membrane filtration method using 100 mL aliquots of water samples as described by Filter Membrane Method 8367 and Filter Membrane Method 8074, respectively by United States Environmental Protection Agency (USEPA). m-ColiBlue24 Broth was used to detect total coliforms and *E. coli* within 24 hours. Red and blue colonies are total coliforms while blue colonies are specific to *E. coli*. The concentration was calculated as cfu/ml which is recommended by National Drinking Water Quality Standard. In Filter Membrane Method 8074, pseudomonas broth was used for detection of pseudomonas species. Some species of pseudomonas are opportunistic pathogens that can inhabit recreational waters such as swimming pools and hot tubs. Pseudomonas Broth is formulated to isolate species of pseudomonas. Pseudomonas Broth contains components that pro-

mote the growth of the pigment pyocyanin, which differentiates *P. aeruginosa* from other species by forming a blue or blue-green color. Other species of pseudomonas grow on this medium without the colony color formation. The concentration was calculated as cfu/ml which is recommended by National drinking Water Quality Standard. All the equipment were autoclaved before the analysis. Each of the samples was run in triplicates and standard method of USEPA (2002) was used throughout the analysis.

2.3 Questionnaire

A questionnaire survey was used to determine reasons for preferring bottled water as source of drinking water and establishing the level of awareness on the safe drinking water among university students of Universiti Putra Malaysia. Sample size was determined using Blaikie (2010) where for small population (<1000) sampling ratios of up to 30% may be required for a high degree of accuracy. A total of 215 university students were calculated based on formula by Blaikie (2010) participated in this pre-tested questionnaire survey. These respondents were interviewed individually using the questionnaire.

A 28-item written questionnaire was modified version of WHO-UNICEF (2006). The questionnaire was divided into three sections namely demographic section, understanding reasons for preferring bottled water as source of drinking water and establishing awareness level on the safe drinking water. Specific numbers were assigned to each questionnaire to guarantee anonymity of responses and easy identification of questionnaires by individuals. Items in the questionnaire were explained during the questionnaire distribution. A standardized score was calculated as maximum score, expressed as a percentage, with 80% and 75% indicating the good level of knowledge and attitude, respectively as indicated by WHO-UNICEF (2006).

2.4. Statistical Analysis

Statistical Package Social Science (SPSS) version 21 for Windows was used for all the analysis. Descriptive analysis was used to determine mean concentration of total coliform, *Escherichia coli* (*E.coli*) and *Pseudomonas aeruginosa* (*P. aeruginosa*) in bottled water and presented in tabular form. WHO Guideline for Drinking Water Quality (2011) and National Standard for Drinking Water Quality (2000) guidelines were also used as comparison to compare microbiological quality of domestic bottled water brands in Malaysia. A standardized score was obtained by subtracting each score from mean, divide it by standard deviation and converted it into percentages (Marcus, 2011; WHO-UNICEF, 2006).

3. Results and Discussion

Presence of total coliform *E.coli*, *P.aeruginosa* and in each brand of bottled water are shown in Table 2. There was no any *E.coli* and *P. aeruginosa* colonies detected in any of 11 brands bottled water while only two brands were detected to have total coliform colonies, in which the two brands were originated from Taiping, Perak and Lenggeng, Negeri Sembilan.

Table 2: Presence of *E.coli*, *P.aeruginosa* and total coliform

Brand code	<i>E.coli</i> (cfu/100mL)	<i>P.aeruginosa</i> (cfu/100mL)	Total coliform (cfu/100mL)
A	<1	<1	5
B	<1	<1	<1
C	<1	<1	<1
D	<1	<1	8
E	<1	<1	<1
F	<1	<1	<1
G	<1	<1	<1
H	<1	<1	<1
I	<1	<1	<1
J	<1	<1	<1
K	<1	<1	<1

Drinking and mineral water samples obtained from different geographical locations has concentrations of the selected minerals lower than the standard limits. Thus, potable water from various manufacturers and locations in Peninsular Malaysia that chosen in this study is safe for consumption, as the minerals concentrations were below the standard limits prescribed by the Malaysian Food Regulations of 1985. Most of mineral water that originated from Taiping, Lenggeng and Johor and drinking water was treated by Syarikat Air Selangor (SYABAS).

Since bottled water is defined as a “food” under federal regulations, it is regulated under the authority of Food and Drug Administration (FDA) while Environmental Protection Agency (EPA) regulates tap water under a much stricter standard. Thus, bottled water, depending upon the brand, may actually be less clean and safe compared to tap water. EPA mandates that local water treatment plants will provide the city residents with a detailed account of tap water’s source and results of any testing, including any contaminant level violations. On the other hand, bottled water companies are under no such directives.

In Malaysia, both mineral water bottle and distilled water bottle use coloured bottle caps which are usually blue or green indicating they are originated from sources other than tap water. In contrast, bottled water originated from tap water has white caps. The results of analysis were compared with National Drinking Water Quality Standard (Ministry of Health Malaysia, 2006) and World Health Organization Drinking Water Standard (World Health Organization, 2006) in which, no detected organism per 100mL of water sample analyzed as the detection limit of the method used is one colony forming unit (CFU) of bacteria. All the 11 brands of domestic bottled water investigated met the criteria and could be said to have good microbiological quality, thus suitable for human consumption since they all recorded a value of <1 for *E.coli* and *P.aeruginosa*. However, exception was for 2 brands of bottled water in which total coliform colonies per 100 ml have been detected.

Table 3 shows level of knowledge of 216 respondents on the microbial quality in domestic bottled brands water in Malaysia. About 123 (57.2%) of the respondents were identified to have poor score (< 80%) while 92 (42.8%) had good score (> 80%) of knowledge on microbial quality in bottled water. The respondents have knowledge on cleanliness aspect (42.3%), followed by contamination aspects 62 (28.8%), turbidity 32 (14.9%), bacteria 28 (13%) and (2) 0.9% was others related to bottled water. A total of 61.4% also knew that bottled water could cause outbreak of waterborne disease.

Table 3: Knowledge scores of the respondent (n=215)

Category	Study Group
	Frequency (%)
Good (score \geq 80%)	92 (42.8)
Poor (score < 80%)	123 (57.2)

A total of 29.8% of respondents have good level attitude and agreed that bottled water is cleaner than tap water without knowing that the bottled water can be contaminated with bacteria contamination (Table 4). Most participants (38.1%) also agreed that compared to tap water, bottled water conferred additional health benefits. These findings are similar to study done by Ward et al. (2009) where bottled water was preferred due to its health benefits. Moreover, about 50.2% respondents were satisfied with bottled water products without knowing the bacterial quality in each brand that they consumed. Aini et al. (2009) reported that bottled water consumption is the most dynamic sector in Malaysian food and beverage industry. In addition, Aini et al. (2009) also found that untreated natural mineral water

is perceived as natural, affordable, convenience and rising social status in Malaysia. This was supported by Frost and Sullivan (2007) who revealed that bottled water in Malaysia is characterized by high level of competition and consolidation among established participants. Growth of domestic bottled water in Malaysia is influenced by several factors such as convenience and portability of bottled water, consumer disillusionments towards municipal water, increased advertising and marketing of bottled water, paradigm shift towards healthy beverages, increase in travel as well as preference to clean, odour-free and colourless water.

Table 4: Attitude scores of the respondents

Category	Study Group Frequency (%)
Good (score \geq 75%)	64 (29.8)
Poor (score < 75%)	151 (70.2)

5. Conclusion

As a conclusion, the study indicated that there was no *E.coli* and *P. aeruginosa* colonies detected in any of 11 brands bottled water while only in two brands where total coliform colonies were detected. The two brands were originated from Taiping (Perak) and Lenggeng (Negeri Sembilan) where more than 1 total coliform colonies were detected. A total of 42.8% of respondents had good scores (> 80%) of knowledge on microbial quality in bottled water. For attitude level, a total of 29.8% indicated to have good scores (>75%) and agreed that bottled water is cleaner than tap water without knowing that the bottled water can be contaminated with bacteria. Findings from this study have raised concern on the microbiological quality of domestic bottled water brands. This study can be considered as a baseline study on microbiological quality of domestic bottled water using university students as a target group.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in the publication of this research.

ETHICAL ISSUES

Ethical approvals for this study were obtained from Research Ethic Committee of Universiti Putra Malaysia. Respondent volunteering participation and their information were kept confidential.

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