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Research Article
Effect of Varying Storage Temperatures on the Microbiological Quality of Street Sold Water in the Kumasi Metropolis, Ghana

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Abstract
The study assessed the effect of varying storage temperatures on the microbiological quality of street sold factory-bagged sachet drinking water in the Kumasi Metropolis. Ten different brands of factory-bagged sachet water samples (30 pieces each), purchased from distributors and vendors were stored at 4, 32 and 26°C temperatures over a six month period. Same brands of the factory-bagged sachet water samples were also bought at random from vendors and the overall hygiene of the unopened bags assessed. Total coliforms, faecal coliforms, *Escherichia coli*, enterococci and Salmonella numbers were determined as an index of quality. Bacterial indicator counts per 100 mL on the unopened bags varied from 9.00-5.56×10^2 for total coliforms, 4.00-3.92×10^2 for faecal coliforms, 3.00-1.75×10^1 for *E. coli*, 2.00-3.71×10^2 for enterococci and 3.0-5.45 for Salmonella. Over the storage period coliform numbers increased by between 118-182% and 128-193% at normal atmospheric temperatures and between 112-154% and 114-165% at room temperatures but decreased by 74-92% and 79-82% at refrigeration temperatures for total and faecal coliforms, respectively. *Escherichia coli* increased by between 102 and 112% and decreased by 59-93% at normal atmospheric, increased by 33-78% at room and decreased by (-) 25-20% at refrigeration temperatures. Enterococci numbers increased by between 112-180% at normal atmospheric, 104-147% at room and decreased by 35-96% at refrigeration temperatures. Salmonella decreased by between (-) 28-47% at normal, room and refrigeration temperatures.

Key words: Factory bagged sachet water, storage temperatures, vendor handling practices, indicator organisms

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The sale and consumption of factory-bagged sachet drinking water has seen an increased patronage over the years in many developing countries, including Ghana. Oyedeji *et al*. (2010) reported that in Nigeria, there is an astronomical increase in the consumption of packaged waters especially bottled and sachet drinking water. Factory-bagged sachet drinking water popularly called 'Pure water' has outnumbered bottled water because of its easy accessibility and affordability (Stoler *et al*., 2012). Today, the easy accessibility to drinking water in packaged forms has resulted in a big and flourishing water production enterprise with hundreds of million litres being sold and consumed every year (Ogundipe, 2008).

In Ghana, the production of factory-bagged sachet water is largely done by small and medium manufacturing companies with varying hygienic standards and practices which often affect the final product quality. While, some employ sophisticated techniques (reverse osmosis), others follow simple filtration and UV disinfection processes (Oyedeji *et al*., 2010; Mashat, 2010). Obiri-Danso *et al*. (2003), Bharath *et al*. (2003) and Warburton *et al*. (1998) in their studies also reported on varying microbial quality of sachet water because of the different processing techniques which often violates international quality standards.

Adekunle *et al*. (2004), Onifade and Ilori (2008) and Dada (2009) reported that the quality monitoring of sachet water in Nigeria have been documented, however, there is little information in scientific literatures on the quality of the many brands of bottled water produced and marketed by local and multinational companies (Oyedeji *et al*., 2010). This situation is no different from what pertains in Ghana. In fact, the high frequency of diseases such as diarrhea, typhoid fever, cholera and bacillary dysentery among the populace has been traced to the consumption of unsafe water and unhygienic drinking water production practices (Mead *et al*., 1999).

The Kumasi Metropolis is the most populous and fastest growing metropolis in Ghana with a population of about 1.889,934 million and a growth rate of 5.47% per annum (Ghana Statistical Service, 2009). In relation to its growing population, the production, sale and consumption of factory-bagged sachet drinking water have increased immensely over the years. The sale of the bulk of the factory-bagged sachet water within the metropolis is in the heart of its trading suburb, Kejetia, which is the busiest trading centre in central Kumasi. It is always choked with traders and shoppers offering various goods and services.

The line of distribution from wholesale through middle level distributors who store in wire-fenced storage cages to street vendors that use unclean containers and the improper handling encourage the introduction of varying microbial populations onto the plastic bags. Secondly, most of the persons involved in the sale of the product are from poor backgrounds, children of school going age, exhibit low levels of personal hygiene and often live on the street or in slums. Thirdly, the varying storage facilities and temperatures depending on the availability of space because of the bulk nature of this factory-bagged water have all contributed to compromising the microbial quality of the product.

The study assessed microbial populations on the unopened sachet and the effect of varying storage temperatures on the microbial quality of factory-bagged sachet drinking water sold in Kejetia, in the Kumasi Metropolis, Ghana.

MATERIALS AND METHODS

Study area: Five sampling sites were selected in the central Kejetia area for the study. Site 1 was located in the northern part of Kejetia which houses a number of local sachet water distributors and vendors and a number of traditional restaurant operators "Local chop bars". Site 2 was located at the Southern portion of Kejetia close to an open public toilet, site 3 was at the eastern part of Kejetia and samples were exposed to the scorching sun, site 4 was to the West of Kejetia with a large urban bus terminal and site 5 was at the centre of Kejetia with sheep and goats wandering in the vicinity.

Sampling: Three each of 10 different brands of 500 mL factory-bagged sachet water samples, sold from aluminum pans, metal baskets and plastic bowls were randomly purchased from different vendors distributed within the central Kejetia area. They were placed in sterilized food bags by the vendors themselves and transported to the laboratory in a cool ice-chest box.

Storage of water samples: The same 10 different brands of the factory-bagged sachet water samples, packed in thirties (30 sachets per bag) were stored at normal atmospheric temperature (32°C), room temperature (26°C) and in a refrigerator (4°C) over a six month period.

Microbial counts: Total and faecal coliforms, enterococci, *E. coli* and Salmonella were enumerated as described by Obiri-Danso *et al*. (2003) and Eaton *et al*. (1992).

Statistical analysis: A two-way randomized analysis of variance (ANOVA) was used to analyze the data using GenStat

version 7.22. A One-way randomized analysis of variance (ANOVA) was also used to analyze the data with one parameter using Duncan's multiple range test.

RESULTS AND DISCUSSION

Microbial assessment on different brands of factory-bagged sachet water sold by vendors at Kejetia: The study shows that there are varying microbial indicator organisms and pathogenic Salmonella on the various brands of the factory-bagged sachet drinking water being sold in Kejetia and other retail outlets within the Kumasi Metropolis.

All the ten different brands of the factory-bagged sachet drinking water selected at random and tested for microbial indicator numbers, bacterial indicator counts on the bags ranged from 8.00 to 3.80×10^1 for total coliforms, 6.00 and 3.00×10^1 for faecal coliforms, 3.00 and 1.90×10^1 for *E. coli* and 1.00 and 1.60×10^1 for enterococci (Table 1). Ideally, the

Table 1: Geometric mean per 100 mL bacterial indicator numbers on different brands of factory-bagged sachet water sold by vendors at Kejetia

Water brand	Mean count	Range
Total coliforms		
Mobile	1.16×10^1	8.00-1.50×10^1
Davis	1.86×10^1	1.70×10^1-2.00×10^1
Rocky	2.77×10^1	2.00×10^1-3.80×10^1
Boadwoo	1.09×10^1	8.00-1.60×10^1
Everkool	2.38×10^1	1.80×10^1-3.00×10^1
SandM	2.13×10^1	1.50×10^1-2.80×10^1
Cobb-Ji	2.04×10^1	1.50×10^1-3.00×10^1
St. Hubert	2.50×10^1	1.50×10^1-4.00×10^1
Dominion	1.25×10^1	1.00×10^1-1.50×10^1
Gofex	2.72×10^1	2.40×10^1-3.00×10^1
Faecal coliforms		
Mobile	7.83	6.00-1.00×10^1
Davis	1.10×10^1	1.00×10^1-1.20×10^1
Rocky	2.11×10^1	1.80×10^1-2.60×10^1
Boadwoo	4.31	2.00-8.00
Everkool	1.50×10^1	1.40×10^1-1.60×10^1
SandM	1.34×10^1	9.00-1.80×10^1
Cobb-Ji	1.59×10^1	1.00×10^1-2.70×10^1
St. Hubert	1.19×10^1	7.00-3.00×10^1
Dominion	8.90	8.00-1.10×10^1
Gofex	1.25×10^1	1.00×10^1-1.50×10^1
Escherichia coli		
Mobile	4.16	3.00-6.00
Davis	7.86	6.00-9.00
Rocky	1.14×10^1	7.00-1.90×10^1
Boadwoo	3.30	3.00-4.00
Everkool	1.06×10^1	9.00-1.20×10^1
SandM	7.23	6.00-9.00
Cobb-Ji	9.74	7.00-1.20×10^1
St.Hubert	5.81	4.00-7.00
Dominion	6.65	6.00-7.00
Gofex	8.14	7.00-8.00
Enterococci		
Mobile	6.00	3.00-9.00
Davis	2.47	1.00-5.00
Rocky	7.83	6.00-1.00×10^1
Boadwoo	3.04	2.00-7.00
Everkool	7.56	6.00-9.00
SandM	8.57	7.00-1.00×10^1
Cobb-Ji	5.31	5.00-6.00
St. Hubert	7.11	4.00-1.00×10^1
Dominion	6.21	5.00-8.00
Gofex	8.32	4.00-1.60×10^1

plastic bags are expected to be free of microorganisms; however, bacterial numbers were on the average; 10^2 for total and faecal coliforms and enterococci, 10^1 for *Escherichia coli* and 3-7 for Salmonella (Table 1). Oyelude and Ahenkorah (2012) reported of higher coliform load ranging from 12-168 CFU/100 mL in sachet water.

Average total and faecal coliforms and *E. coli* numbers were high on the Rocky brand and enterococci on the SandM brand (Table 1). Significant differences were recorded between brands for total coliforms ($p<0.017$) and *E. coli* ($p<0.007$). However, no statistically significant differences were recorded between brands for faecal coliforms ($p>0.05$) and enterococci ($p>0.05$) (Table 1).

Sources of these microorganisms vary. Most of the vendors are children between the ages of 9 and 15 years and even younger who are mostly illiterates. Besides, the start-up capital for the sale of factory bagged sachet water is small and affordable and hence, persons from poor family backgrounds who often lack basic hygienic education dominate as vendors. The ready to sell sachet bags are often cooled in old, often rusty and unsuitable containers; rubber buckets, aluminum utensils and sometimes old unserviceable freezers. In most instances, ice blocks/cubes manufactured from contaminated water sources are placed on top of these plastic bags to cool. Again, these vendors go all day without washing their hands but continue to fetch the bags from the selling receptacles for their clients from morning till late in the evening when they close. Ashbolt (2004) and Obiri-Danso *et al*. (2003) attributed contamination of sachet drinking water bags to poor personal hygiene of handlers and the general environmental hygiene. Edoh *et al*. (2005) reported that tap water, as raw material for most sachet water production companies may be contaminated with coliforms from underground broken pipelines and the unhygienic production environments.

Mean Salmonella: Mean Salmonella numbers on the different brands of the factory-bagged sachet water were generally low and varied between 3.30 and 7.65 with no statistically significant differences ($p>0.05$) between the brands.

Total heterotrophic bacteria: Total heterotrophic bacteria numbers varied between 4.13×10^5 and 1.98×10^6 with average counts being low (7.61×10^5) on Dominion and high (1.20×10^6) on Boadwoo (Table 2). There were no statistically significant differences in counts between the brands ($p>0.05$). There may be no evidence that high counts of total heterotrophic bacteria may have led to any health problems but they can be good indicators of the overall quality of production (Fereira *et al*., 1994). This study shows that there could be some health risks in the consumption of sachet drinking water without modifications in processing, handling, sources and quality of bags used (Tortora *et al*., 2002; Valent *et al*., 2004; Shiklomanov, 2000).

Geometric mean per 100 mL of indicator bacteria, Salmonella and heterotrophic indicator numbers in ten different brands of factory-bagged sachet water stored at different temperatures.

Total coliforms: Due to high cost of refrigeration and lack of space in retail outlets (the sachet bags which are often packed in 30s per bigger bag are bulky and occupy a lot of space), most of the factory-bagged sachet water is often displayed in metal cages outside of shops. As a result, they are exposed to sunlight, rain and varying temperatures which make it favorable for bacteria growth, especially for thermotolerant coliforms. Mean indicator bacterial numbers and Salmonella counts contained in the ten different brands of factory-bagged sachet water stored under varying storage temperatures indicate that the microbial quality of factory-bagged sachet drinking water differed under varying storage temperature regimes (Table 3). Irrespective of the brand of factory-bagged sachet water tested, initial geometric mean total coliform numbers varied between 9.00 and 1.50×10^1.

Table 2: Geometric mean per 100 mL total heterotrophic bacteria numbers on different brands of factory-bagged sachet water sold by vendors in Kejetia within the Kumasi metropolis

Sachet water brands	Mean count	Range
Mobile	1.11×10^6	7.76×10^5-1.51×10^6
Davis	8.90×10^5	4.13×10^5-1.53×10^6
Rocky	8.59×10^5	4.90×10^5-1.16×10^6
Boadwoo	1.20×10^6	4.63×10^5-1.98×10^6
Everkool	1.17×10^6	1.13×10^6-1.23×10^6
SandM	9.61×10^5	6.03×10^5-1.30×10^6
Cobb-Ji	9.07×10^5	7.66×10^5-1.24×10^6
St. Hubert	1.14×10^6	7.66×10^5-1.67×10^6
Dominion	7.61×10^5	4.20×10^5-1.26×10^6
Gofex	8.07×10^5	5.33×10^5-1.19×10^6

Table 3: Mean total coliform numbers (Geometric mean/100 mL sample) at different storage temperatures and statistical comparison between the brands

Sachet water brands	Initial TC levels	Normal atmospheric temperature (32°C)	Percentage change in TC levels at NAT	Refrigerator temperature (4°C)	Percentage change in TC levels at REF	Room temperature (26°C)	Percentage change in TC levels at RT
Mobile	1.50×10^{1}	5.56×10^{2c} (±65.42)	134	1.09×10^{2a} (±68.02)	74	3.01×10^{2b} (±29.94)	112
Davis	1.00×10^{1}	4.19×10^{2c} (±54.92)	151	7.60×10^{1a} (±39.33)	81	3.23×10^{2b} (±36.74)	141
Rocky	1.10×10^{1}	3.15×10^{2c} (±65.42)	141	1.47×10^{2a} (±60.22)	108	2.49×10^{2b} (±41.19)	130
Boadwoo	9.00	3.71×10^{2b} (±126.24)	170	1.36×10^{2a} (±118.62)	124	1.64×10^{2a} (±32.04)	132
Everkool	1.30×10^{1}	2.99×10^{2c} (±27.57)	123	1.38×10^{2a} (±44.12)	92	2.26×10^{2b} (±44.72)	112
SandM	9.00	3.35×10^{2b} (±48.34)	165	1.84×10^{2a} (±59.13)	138	2.35×10^{2a} (±69.47)	149
Cobb-Ji	1.40×10^{1}	3.22×10^{2b} (±47.22)	118	1.01×10^{2a} (±30.17)	74	2.87×10^{2b} (±56.01)	113
St. Hubert	9.00	4.76×10^{2b} (±64.50)	182	1.28×10^{2a} (±55.05)	122	1.82×10^{2a} (±54.56)	137
Dominion	9.00	3.70×10^{2b} (±64.11)	170	2.15×10^{2a} (±48.99)	145	2.63×10^{2a} (±37.82)	154
Gofex	1.00×10^{1}	4.39×10^{2c} (±55.65)	164	1.84×10^{2a} (±21.68)	126	3.15×10^{2b} (±34.45)	149

Figures in brackets are standard deviation, TC: Total coliform, NAT: Normal atmospheric temperature, REF: Refrigerator, RT: Room temperature, mean in a column with same superscripts are not significantly different (p>0.05)

Table 4: Mean faecal coliform numbers at different storage temperatures and statistical comparison between the brands

Geometric mean/100 mL sample

Sachet water brands	Initial FC levels	Normal atmospheric temperature (30°C)	Percentage change in FC level at NAT	Refrigerator (4°C)	Percentage change in FC level at REF	Room temperature (26°C)	Percentage change in FC level at RT
Mobile	8.00	3.92×10^{2c} (±77.05)	184	9.36×10^{1a} (±47.61)	116	1.93×10^{2b} (±56.92)	151
Davis	8.00	2.01×10^{2b} (±33.86)	145	4.93×10^{1a} (±28.81)	79	1.73×10^{2b} (±44.91)	138
Rocky	9.00	1.54×10^{2a} (±47.75)	165	1.15×10^{2a} (±56.12)	148	1.55×10^{2a} (±31.25)	163
Boadwoo	4.00	2.22×10^{2b} (±39.37)	193	7.00×10^{1a} (±67.65)	131	1.32×10^{2a} (±39.33)	165
Everkool	7.00	1.67×10^{2b} (±86.87)	128	9.24×10^{1a} (±32.04)	103	1.21×10^{2a} (±49.56)	114
SandM	6.00	1.76×10^{2a} (±52.31)	152	1.39×10^{2a} (±71.67)	140	1.38×10^{2a} (±64.81)	140
Cobb-Ji	8.00	1.72×10^{2b} (±23.38)	143	4.75×10^{1a} (±20.00)	82	1.46×10^{2b} (±47.19)	135
St. Hubert	8.00	2.08×10^{2b} (±83.29)	160	7.97×10^{1a} (±43.20)	113	1.28×10^{2a} (±49.30)	137
Dominion	6.00	2.37×10^{2c} (±58.54)	180	1.04×10^{2a} (±44.72)	137	1.67×10^{2b} (±63.69)	161
Gofex	5.00	2.32×10^{2b} (±78.91)	144	1.04×10^{2a} (±25.03)	108	2.16×10^{2b} (±48.58)	140

Figures in brackets are standard deviation, FC: Faecal coliform, NAT: Normal atmospheric temperature, REF: Refrigerator, RT: Room temperature, mean in a column with same superscripts are not significantly different (p>0.05)

Numbers of total coliforms increased steadily by between 118-182% and 112-154% in all the different brands during storage at normal atmospheric temperatures (32°C) and room temperature (26°C), respectively. Increases were significant (p<0.001) in the Mobile, Boadwoo, Everkool, SandM and Gofex brands stored at normal atmospheric temperatures and in Mobile, Boadwoo, Everkool, SandM, Cobb-ji, St. Hubert and Gofex stored at room temperatures (Table 3). However, samples stored at refrigerator (4°C) temperatures recorded decreases of between 74-92% with no significant differences between the brands.

Faecal coliforms: Initial geometric mean numbers of faecal coliforms in the ten different brands of the factory-bagged sachet water samples varied between 4.00 and 5.00×10^{2}. Irrespective of the brand, the numbers increased between 128-193% at normal atmospheric temperature (32°C) and 112-165% during storage at room temperature (26°C). These increases were significant (p<0.001) in all the brands at normal atmospheric temperatures but at room temperatures, Rocky, Boadwoo, Everkool and SandM did not have any significant differences between them (Table 4). Samples stored at refrigerator (4°C) temperatures recorded decreases of between 79-82% with no statistically significant differences between the brands. Some studies have reported on effect of storage conditions on microbial quality of drinking water. Dodoo *et al.* (2006) reported that sachet water stored in places where they were exposed to sunlight and unfavorable temperatures had over 45% of the samples with as high as 9.80×10^{6} CFU/100 mL of total coliforms. Stickler (1992) has also shown that microbial numbers in processed water are often initially low, but can increase rapidly to high numbers depending on storage conditions.

***Escherichia coli*:** Geometric mean numbers of *Escherichia coli* varied from the initial 3.00 to between 7.00 and 2.00×10^{1} in all the brands stored at normal atmospheric temperature with increases of between 102-112%. Decreases were recorded in six of the brands; 93% in Gofex, 88% in Boadwoo, 62% in Cobb-ji, 59% in Davis, 50% in Everkool and 39% in SandM brands. *Escherichia coli* numbers in samples stored at room temperatures decreased by between 33-78% and in the

refrigeration by -25-20%. Significant differences ($p<0.001$) in *E. coli* numbers at normal atmospheric temperatures were also recorded in Mobile, Davis and Dominion. Except for the St. Hubert's brand, all of the other brands showed no statistically significant differences at room temperature.

Enterococci: At normal atmospheric temperatures enterococci numbers increased between 112- 180% except in the Cobb-ji brand which decreased by 93%. At room temperatures, numbers decreased in two of the brands; 98% in Mobile and 90% in Davis but increased 104-147% in the other eight brands with statistically significant differences ($p<0.001$) between them. Numbers decreased by 35-96% in the refrigerator with no significant variations amongst them.

Mean Salmonella: Geometric mean Salmonella numbers varied from the initial 3.00 to between 4.00 and 1.20×10^1 in all the brands. After six weeks of storage at normal atmospheric temperatures, in the refrigerator and at room temperatures, Salmonella numbers decreased by -28-47% in all the brands (Table 5). Significant differences were observed in the brands at normal atmospheric temperatures, no statistically significant differences in refrigerator samples but statistically significant differences in Everkool and St. Hubert at room temperature.

Heterotrophic bacteria: Initial geometric mean total heterotrophic bacteria numbers varied from 4.30×10^4-4.30×10^5 (Table 6). Total heterotrophic bacteria counts decreased by between 9-38, 8-38 and 11-31% in all the brands at normal atmospheric, room and refrigerator temperatures respectively. There were significant differences between samples stored at normal and room temperatures but there were no significant differences in that stored in the refrigerator (Table 6).

Stoler *et al.* (2012) reported that higher temperatures is a risk factor for not only increased microbial growth, but the release of contaminants from some plastics. In this study, total and faecal coliforms, enterococci, Salmonella and total

Table 5: Mean Salmonella numbers at different storage temperatures and statistical comparison between the brands

Geometric mean/100 mL sample

Sachet water brands	Initial Salmonella levels	Normal atmospheric temperature (32°C)	Percentage change in Salmonella levels at NAT	Refrigerator (4°C)	Percentage change in Salmonella levels at REF	Room temperature (26°C)	Percentage change in Salmonella levels at RT
Mobile	3.00	3.30^{a} (±0.52)	-18	3.00^{a} (±0.00)	-25	3.00^{a} (±0.00)	-25
Davis	3.00	3.30^{a} (±0.52)	-22	3.00^{a} (±0.00)	-28	3.15^{a} (±0.41)	-26
Rocky	3.00	4.45^{b} (±2.32)	12	3.00^{a} (±0.00)	-17	3.00^{a} (±0.00)	-17
Boadwoo	3.00	5.45^{b} (±2.51)	17	3.15^{a} (±0.41)	-22	3.53^{a} (±1.21)	-12
Everkool	3.00	7.09^{c} (±2.74)	47	3.00^{a} (±0.00)	-17	4.24^{b} (±2.42)	8
SandM	3.00	3.53^{a} (±1.21)	-3	3.15^{a} (±0.41)	-14	3.53^{a} (±1.21)	-3
Cobb-Ji	3.00	4.16^{a} (±1.37)	29	3.00^{a} (±0.00)	0	3.30^{a} (±0.52)	8
St. Hubert	3.00	5.00^{b} (±2.16)	45	3.00^{a} (±0.00)	0	3.97^{0b} (±2.34)	22
Dominion	3.00	3.15^{a} (±0.41)	2	3.00^{0a} (±0.00)	-2	3.37^{a} (±1.22)	8
Gofex	3.00	3.15^{a} (±0.41)	4	3.00^{a} (±0.00)	0	3.15^{a} (±0.41)	2

Figures in brackets are standard deviation, NAT: Normal atmospheric temperature, REF: Refrigerator, RT: Room temperature, (%): Percentage, mean in a column with same superscripts are not significantly different ($p>0.05$)

Table 6: Mean total heterotrophic bacteria numbers at different storage temperatures and statistical comparison between the brands

Geometric mean/100 mL sample

Sachet water brands	Initial TVC levels	Normal atmospheric temperature (30°C)	Percentage change change in TVC levels at NAT	Refrigerator (4°C)	Percentage change in TVC levels at REF	Room temperature (26°C)	Percentage change in TVC levels at RT
Mobile	4.13×10^5	1.49×10^{6b} (±397872.68)	9	3.26×10^{5a} (±490587.40)	-3	1.46×10^{6ab} (±382692.26)	8
Davis	3.13×10^5	1.49×10^{6b} (±445383.73)	10	1.74×10^{5a} (±482397.52)	-6	1.24×10^{6ab} (±505259.01)	8
Rocky	4.30×10^5	1.65×10^{6b} (±411412.53)	10	9.40×10^{4a} (±278524.27)	-11	1.31×10^{6b} (±763258.65)	8
Boadwoo	1.30×10^5	1.43×10^{6b} (±469674.36)	13	3.19×10^{5a} (±347446.93)	1	1.19×10^{6ab} (±355252.59)	12
Everkool	1.23×10^5	1.87×10^{6b} (±571660.53)	13	7.18×10^{5a} (±317025.18)	6	1.36×10^{6ab} (±434244.48)	11
SandM	3.13×10^5	2.54×10^{6b} (±855510.76)	14	1.08×10^{6a} (±517087.87)	7	1.52×10^{6b} (±2818339.82)	10
Cobb-Ji	4.33×10^4	2.64×10^{6b} (±1201943.1)	18	1.66×10^{5a} (±284394.09)	-3	1.23×10^{6b} (±2914101.61)	12
St. Hubert	7.66×10^4	1.40×10^{6b} (±417101.15)	22	3.22×10^{5a} (±240668.03)	9	7.87×10^{5ab} (±344861.71)	17
Dominion	8.60×10^4	9.58×10^{5a} (±675683.58)	9	5.21×10^{5a} (±397470.33)	4	1.22×10^{6a} (±739502.45)	11
Gofex	4.30×10^4	9.37×10^{5a} (±1560475.1)	38	4.49×10^{5a} (±133207.61)	31	8.76×10^{5a} (±464076.90)	38

Figures in brackets are standard deviation, TVC: Total viable counts, NAT: Normal atmospheric temperature, REF: Refrigerator, RT: Room temperature, mean in a column with same superscripts are not significantly different ($p>0.05$)

heterotrophic bacteria numbers increased at storage temperature of 26°C and above but *E. coli* numbers decreased which may be due to their sensitivity to temperature. Nsaze *et al*. (1999) showed that mesophilic organisms multiply more easily between 25 and 37°C. None of the vendors kept their factory bagged sachet in the refrigerator which explains the increases in bacterial numbers. Even though the Ghana Environmental Protection Agency Act (GEPA., 1994) indicates that drinking water products should not be exposed to sunlight, most of the vendors and distributors do not comply with these directives. This is because vendors and distributors do not have the capacity to do so as they are not informed of the consequences and the regulations are not enforced. At 4°C however, there was a general decrease in the levels of bacteria due to the lower temperatures not being suitable for mesophilic organisms as it slows down their vital activities and affect viability of the organisms.

The results of this study have several implications for consumers since most of the water used in the production are drawn from various sources, principally from underground water; boreholes and wells (many of which are shallow and contaminated through surface runoffs). Additionally, the plastic bags used in bagging the water are not kept under hygienic conditions as some are observed to have grown mouldy before use (Hunter and Burge, 1987; Warburton *et al*., 1986). The water not being well processed before sale and stored over long periods of time before use may also explain the high microbial counts (Ajayi *et al*., 2008; Oyedeji *et al*., 2010; Obiri-Danso *et al*., 2003).

CONCLUSION

The present study has shown that the quality of factory bagged sachet drinking water sold on the streets of the Kumasi metropolis are contaminated with varying microbial numbers due to the handling practices of the vendors. Storing these factory bagged sachet water over longer periods of time especially at normal atmospheric and room temperatures increases the levels of microorganisms in them and makes it unsuitable for consumption and sale to the general public.

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