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Physicochemical Properties of Sachet Water Sold at Mont-Bouet Market in Libreville (Gabon)

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Abstract

This study focuses on the physicochemical quality and sales conditions of water sold in plastic bags at Mont-Bouet market in Libreville. For this, a data collection campaign was carried out during one month. The results show that sachet water is a drinking water available throughout the market. It is sold in large quantity by street or stall sellers and shopkeepers. Seven brands of sachet water are present on the market. Sachet water is sold in poor hygienic conditions. Sellers are barely controlled by the competent authorities. Most of these brands label fake scientific information on the contents of different physicochemical parameters. The physicochemical analysis of the seven brands showed poorly mineralized water with low conductivity values and low chloride, nitrate and phosphate ions contents. Waters are fresh with low levels of calcium and magnesium. The potential of hydrogen (pH) values are close to neutral. The turbidity values obtained are generally low, except for two brands presenting a turbidity above the limit (WHO standard).

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Introduction

In many African regions, water consumption from sources other than conventional networks is expanding. These are well water (Tchoumou *et al.*, 2023) or borehole water (Fambi *et al.*, 2021), rainwater (Dovonou *et al.*, 2020) or sachet water (Konan, 2022; Hissein, 2020; Kordowou *et al.*, 2023).

These alternative water sources have greatly developed due to the difficult access to drinking water, the lack of water supply equipment (Sahirou, 2020; Fambi *et al.*, 2021), aging facilities (Bigoumou *et al.*, 2022), the farness of drinking water points (Dovonou *et al.*, 2020), water cuts. For example, in Benin, despite progress in the establishment of drinking water supply networks, a

segment of the population still uses alternative water sources (traditional wells, cisterns, private water points) (Hoteyi *et al.*, 2014). In many regions, the drinking water requirement leads to high consumption of sachet water. For example, in Parakou in Benin, sachet water has been sold for a few years. It is a highly demanded resource (Akiyo, 2017). In addition, it is sold cheap (Konan, 2022).

But, the quality of sachet water is raising more and more questions. Indeed, it is produced in large quantity with little concern for the quality and hygiene (Akiyo, 2017). In Abidjan, the sachet water sector often escapes the control of hygiene services (Konan, 2022). This poses a food security problem for people with low income consuming this type of water. As they are not concerned

the selling conditions of sachet water, they are exposed to a high risk of water-borne diseases (WHO, 2017; N'vekounou, 2019; Sahirou *et al.*, 2020). It constitutes the primary cause of infant mortality in Africa. A study published in Congo indicates sachet constitutes a significant risk factor for contracting cholera (Mbalakingebe *et al.*, 2021). Other pathologies such as typhoid fever, diarrhea, stomach aches (Akiyo, 2017) are mentioned. In addition, plastic bags water can contain microorganisms such as coliforms, enterococci (Dieng *et al.*, 2021), salmonella (Sahirou *et al.*, 2020). Sachet water is particularly appreciated in crowded places such as public schools and markets, which often concentrate the middle and working class. As in other capitals of the sub-region, in Libreville, sachet water has become very popular. We find it in the majority of small street shops in neighborhoods. Sachet water is available in where the drinking water supply is poor. However, for most brands found in stores, little information are available on the manufacturing conditions, on the packaging process and even on the composition of this water. The main objective of this study is to contribute to a better understanding of the health risks related to the consumption of water sold in plastic bags at Mont-Bouet market in Libreville. For this, information on the chemical composition of the water indicated on the plastic bags were collected and interpreted. The conditions of sale were also reviewed. In addition, a physicochemical analysis was carried out on the plastic bags found on sale in the market.

Materials and Methods

Choice of study area

Born in the 1970s, Mont-Bouet market is located in the Northwest of Libreville, the Gabonese capital (figure 1). Previously located on the outskirts of the city center, the market has been absorbed by the extension of the urban fabric. Mont-Bouet market is the largest market in the country, with nearly 1,400 companies listed, including nearly 487 in the informal sector. Mont-Bouet market was chosen because it is the largest market in the Gabonese capital.

It is a very busy place and is characterized by high consumption of sachet water by sellers and customers. Indeed, Mont-Bouet market is the workplace of many sellers who have few drinking water points, even though they spend all their days over there. Immediately available, sachet water is then popular, especially because it is inexpensive. Likewise, customers, often on

a small budget, prefer to drink sachet water because of its low price. This study was based on the observation of the conditions of sale and conservation of sachet water on the study site and the data collection read directly from the plastic bags. In addition, a physicochemical analysis of the different brands of plastic bags water was carried out.

Data collection and processing

Data collection was carried out by a team of four investigators deployed in Mont-Bouet market for one month (August 2023). Information indicated on the packaging were recorded. Data processing was done using Excel software.

Sampling

Seven brands of sachet water, numbered from A to G, were identified and randomly sampled at a rate of three samples per brand. Samples were carefully labeled and put in an icebox to be sent to the analysis laboratory (laboratoire pluridisciplinaire des sciences LAPLUS) in Libreville. Nine physicochemical parameters were then determined: pH, electrical conductivity, turbidity, Total hardness, calcium (Ca^{2+}), magnesium (Mg^{2+}), chloride (Cl^-), phosphate (PO_4^{3-}) and nitrate (NO_3^-).

On-site Analysis

pH, electrical conductivity and turbidity were recorded on-site using a multimeter (HI 991300 HANNA model) for the first two parameters and a turbidimeter (HI 98713 HANNA model) for the last parameter. Before taking the measurements of pH, a calibration was done with the three standard solutions (pH 4.0 – pH 7.0 – pH 10.0).

The value of each sample was taken after submerging the pH probe in the water sample and holding for a few minutes to achieve a stabilized reading. After the measurement of each sample, the probe was rinsed with deionized water.

For conductivity measurements, the probe was first calibrated with a standard solution of known conductivity before measuring the conductivity of the samples. The probe was then submerged in the water sample and the reading was recorded. After each measurement, the probe was rinsed with deionized water. After a calibration, turbidity was measured by introducing into the turbidimeter, the cell containing the water sample.

Laboratory Analysis

Total hardness, calcium (Ca^{2+}), magnesium (Mg^{2+}) were determined by volumetric metric method with EDTA. Total hardness was determined in the presence of Eriochrome Black -T indicator and a pH 10 buffer solution and calcium titration was carried out in the presence of PR indicator, at a pH of 12 (Rodier *et al.*, 2009). Concentration of chloride ions (Cl^-) was determined by titration by the Mohr method (Rodier *et al.*, 2009). Concentrations of phosphate (PO_4^{3-}) and nitrate (NO_3^-) ions were determined by colorimetric method using a WEG 7100 spectrophotometer (Rodier *et al.*, 2009).

All (on-site and laboratory) analyses were carried out in triplicate for each parameter, the results correspond to the average of the three values.

Results and Discussion

Selling conditions of sachet water

At Mont-Bouet market, sachet water is sold by street vendors, stall sellers and shopkeepers. Itinerant and stall sellers are found inside the market while shopkeepers are found on the different main streets providing access to the market. During this study, 7 street sellers, 16 stall sellers and 9 shopkeepers. That is, 32 sachet water sellers were identified at Mont-Bouet market. Only the 7 street vendors sell exclusively sachet water. The other two types of merchants also sell other consuming products. Seven brands of sachet water were listed at Mont-Bouet market. In most cases, water is packaged in 33 cl plastic bags and sold at 50 fcfa. We also find 50cl bottle-shaped plastic bags at 100 fcfa (figure 2). The sachet water are consumed fresh. The stall sellers and shopkeepers initially stored it on the ground and gradually placed them in refrigerators, though poorly maintained (figure 3).

Chemical composition indicated on packaging

Just like bottled mineral water, some information are marked on the packaging. These are the brand, the capacity, the expiration date, an advertising message praising the quality of the water, a bagging address and the chemical composition. Among the seven brands listed at Mont-Bouet market, only three of them indicate these different information in a clear and readable manner. In addition, only six brands indicate a chemical composition. But each time there are errors. Chemical

symbols are wrong, pH values given are both acidic and basic (figure 4). Among the seven brands, only five indicate the capacity of the plastic bag, but for two of them the capacity indicated is wrong and does not correspond to the real volume (table 1).

Physicochemical Analysis

A Physicochemical analysis was carried out on the seven brands of sachet water found at Mont-Bouet market. The results are presented in tables 2 to 4.

At Mont-Bouet market, the large number of sachet water sellers ensures its availability throughout the market, especially street sellers roaming the streets all day. This large number of sellers proves the booming of the sachet water business. This observation is also made in other cities in the sub-region like in Parakou (Akiyo, 2017), Dakar (Dieng *et al.*, 2021), Abidjan (Konan, 2022), Kinshasa (Mbala-Kingubeni *et al.*, 2021) and Niamey (Sahirou *et al.*, 2020). The sale of sachet water is a significant source of income for sellers (Dieng *et al.*, 2021). As Akiyo (2017) points in his study, the sale of plastic bags water contributes to financial empowerment. At Mont-Bouet market, the diversity of plastic bags water reflects its high consumption. Today, we find more sachet water brands than bottled mineral water on the market. Studies observe a proliferation of sachet water brands in markets, with approximately thousands sold in a day (Dieng *et al.*, 2021) or even dozens of bales flowed per day (Konan, 2022). Sachet water are sold in insufficient and deplorable hygienic conditions.

It reflects the unsanitary state of Mont-Bouet market. In fact, basic hygienic rules are not respected. This could be due to the difficult access of drinking water in the market, the insufficient collection of garbage in the market, the incivility of sellers regarding hygiene and probably to not dissuasive sanction measures. The lack of hygiene is a risk factor for people's health. It is also observed in other cases where unsanitary and illegal production sites are denounced, as well as dangerous hygienic practices (Konan, 2022) or even clandestine, unsanitary production factories, surrounded by garbage and stagnant water (Kordowou *et al.*, 2023). The production conditions of this water often escape food safety authorities (Konan, 2022). The lack of information on the plastic bags water shows the inadequacy of health controls. A study sachet water production unit in Togo revealed an unsanitary environment around these units, which generally do not apply any health control measures (Avodeh *et al.*, 2022).

Table.1 Information on the sachet water

	Readability	Chemical composition		Volume	
		Indicated	Wrong	Indicated	Wrong
Brand A	-	+	+	-	
Brand B	-	-		+	
Brand C	-	+	+	+	+
Brand D	+	+	+	+	+
Brand E	+	+	+	+	
Brand F	+	+	+	+	
Brand G	-	+	+	-	

+ indicates a positive response for the selected criterion

- indicates a negative response for the selected criterion

Table.2 Average values of physicochemical parameters (pH, electrical conductivity, turbidity) measured

	pH	Electrical Conductivity ($\mu\text{S.cm}^{-1}$)	Turbidity (NTU)
Brand A	7.2 \pm 0.1	185.8 \pm 3.3	5.9 \pm 0.6
Brand B	7.0 \pm 0.1	162.5 \pm 1.8	0.9 \pm 0.2
Brand C	6.9 \pm 0.2	203 \pm 2	2.5 \pm 0.2
Brand D	7.4 \pm 0.1	118.9 \pm 4.6	3.3 \pm 0.4
Brand E	6.9 \pm 0.3	201 \pm 2.5	2.4 \pm 0.3
Brand F	7.2 \pm 0.2	180 \pm 0.9	6.6 \pm 0.4
Brand G	7.1 \pm 0.2	201 \pm 3.8	2.8 \pm 0.3

Table.3 Average values of chemical parameters (calcium, total hardness, magnesium) measured

	Calcium Ca^{2+} (mg/L)	Total Hardness ($^{\circ}\text{F}$)	Magnesium Mg^{2+} (mg/L)
Brand A	10.8 \pm 1.3	2.0 \pm 0.1	3.1 \pm 0.3
Brand B	10.6 \pm 0.6	2.2 \pm 0.2	2.8 \pm 0.2
Brand C	13.0 \pm 0.8	1.9 \pm 0.3	3.5 \pm 0.3
Brand D	9.4 \pm 0.3	1.6 \pm 0.2	2.1 \pm 0.3
Brand E	12.5 \pm 0.7	2.5 \pm 0.2	3.6 \pm 0.2
Brand F	11.6 \pm 1.2	2.7 \pm 0.4	3.0 \pm 0.4
Brand G	9.9 \pm 0.2	1.4 \pm 0.2	2.0 \pm 0.2

Table.4 Average values of chemical parameters (chloride, phosphate and nitrate) measured

	Chloride Cl^{-} (mg/L)	Phosphate PO_4^{3-} (mg/L)	Nitrate NO_3^{-} (mg/L)
Brand A	1.9 \pm 0.2	4.5 \pm 0.4	5.7 \pm 0.3
Brand B	2.0 \pm 0.4	2.9 \pm 0.3	3.4 \pm 0.4
Brand C	2.3 \pm 0.1	0.8 \pm 0.1	3.9 \pm 0.3
Brand D	4.1 \pm 0.4	1.5 \pm 0.2	4.1 \pm 0.2
Brand E	3.8 \pm 0.3	3.3 \pm 0.1	2.6 \pm 0.4
Brand F	5.6 \pm 0.4	5.0 \pm 0.4	6.3 \pm 0.2
Brand G	2.6 \pm 0.3	2.7 \pm 0.3	2.5 \pm 0.2

Figure.1 Location of Mont-Bouet Market in Libreville municipality (from Bigoumou *et al.*, 2022)

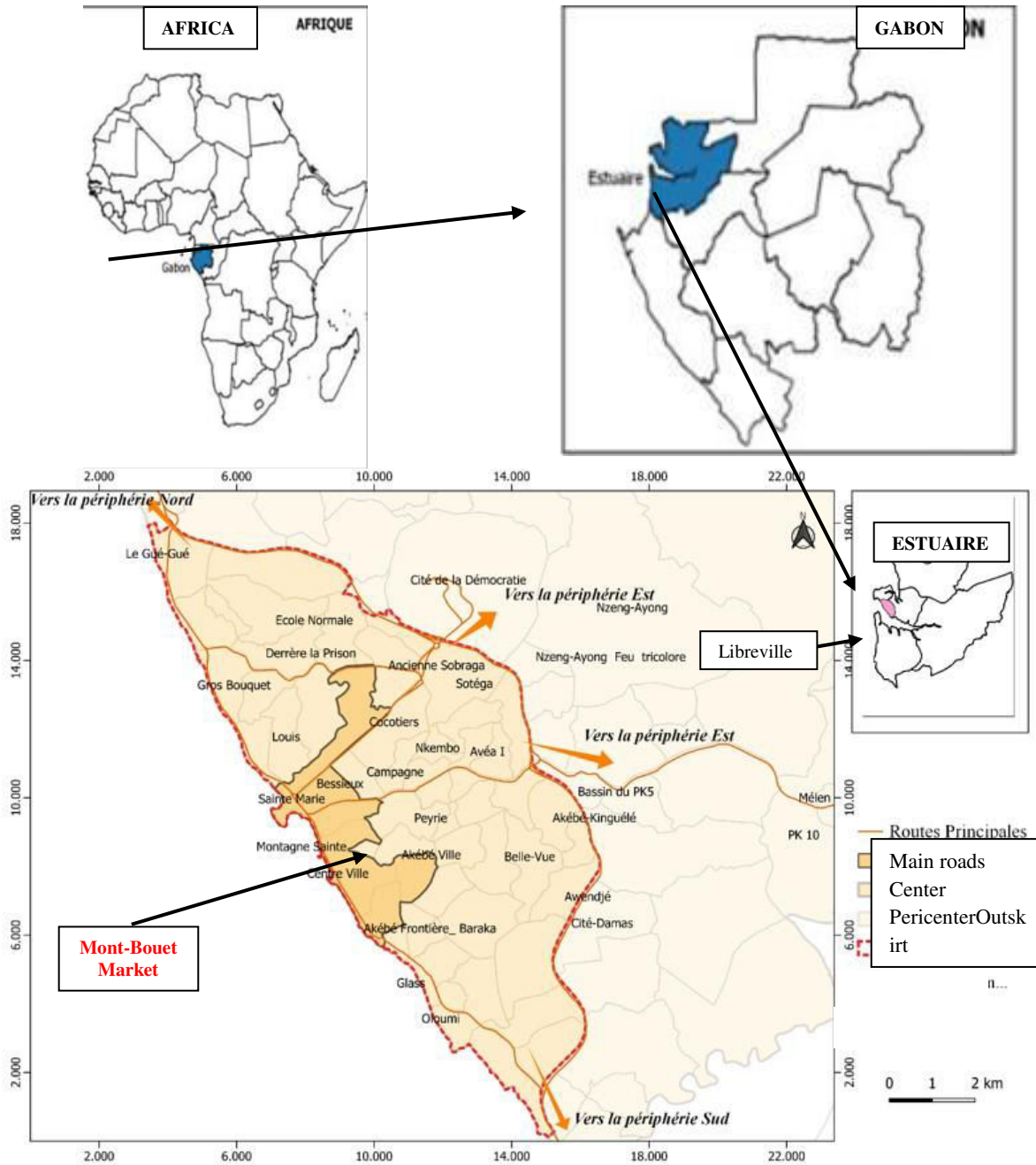


Figure.2 Variety of sachet water sold at Mont-Bouet market



Figure.3 Storing conditions of sachet water at Mont-Bouet



Figure.4 Chemical composition labeled on packaging

PH	>6.5ou≤8.5
Calcium (ca ²⁺)	Nd
Magnesium	(mg ²⁺)50
Sodium (Na ³)	300
Florures (F)	1.5
Nitrates (NO ₂)	50
Phosphores Total	nd

PH.....	7.5
Calcium.....(Ca ²).....	2mg/l
Magnésium(Mg ²).....	1.2mg/l
Sodium(Na).....	16.7mg/l
Fluorures(F).....	0.5 mg/l
Nitrates(No ₂).....	0.05mg/l
Nitrates(No ₁).....	0.5mg/l

The information displayed on the plastic bags water sold at Mont-Bouët market contains several errors. This reveals the low level of scientific knowledge of the producers. Thus, the marketing of sachet water seems to correspond simply to an activity of bagging drinking water already available and not to an activity of producing drinking water. A survey carried out in Porto-Novo in Benin attests the low level of education

(secondary education level) of sachet water producers (Hoteyi *et al.*, 2014). Another study shows that most production factory employees have a primary education level (Kordowou *et al.*, 2023). The numerous errors in chemical composition of plastic bags water are unfortunately common and often noted in the literature (Sahirou *et al.*, 2020; Konan, 2022). Therefore, the information indicated on the plastic bags are unreliable.

Physicochemical analysis carried out on sachet water from Mont-Bouet market show that pH values are close to neutral, with an average value of 7.1. These pH values comply with WHO standards for drinking water (6.5 to 9.5). In the literature, values of pH found also complies with these WHO standards with average values of 6.1 (Sahirou *et al.*, 2020), 7.2 (Dieng *et al.*, 2020) and 7.3 (Hissein, 2020). Some studies indicate acidic pH with average values of 5 (Hoteyi *et al.*, 2014; Kordowou *et al.*, 2023). The turbidity values obtained in our study are generally low with an average value of 3.0 NTU. However, 2 brands (A and F) have high turbidity (5.9 and 6.6 NTU respectively), higher than the maximum value (5 NFU) set by the WHO for drinking water. The obtention of a high or low turbidity, depending on the brand of sachet water, is reported in the literature (Dieng *et al.*, 2021). Indeed, turbidity values obtained are sometimes high and above 6 NTU (Sahirou *et al.*, 2020), sometimes low and close to 1 NTU (Hoteyi *et al.*, 2014; Hissein, 2020; Dovonou *et al.*, 2020). Turbidity corresponds to a reduction in transparency due to the presence of undissolved materials. The high values obtained for the two brands A and F (Mont-Bouet market) could indicate the presence of pathogenic elements in the water. The sachet water sold at Mont-Bouet market is poorly mineralized, with an average conductivity of $178.8 \mu\text{S}\cdot\text{cm}^{-1}$ and very soft with an average hardness of $2.0 \text{ }^\circ\text{F}$. Hardness has a natural character linked to the leaching of the field crossed (Rodier *et al.*, 2009). In our study, it relates to the calcium and magnesium contents, which are respectively about 11.1 and 2.8 mg/L. In the literature, sachet water often presents low conductivity with average values of $72 \mu\text{S}\cdot\text{cm}^{-1}$ (Dovonou *et al.*, 2020), $174 \mu\text{S}\cdot\text{cm}^{-1}$ (Kordowou *et al.*, 2023), $177.5 \mu\text{S}\cdot\text{cm}^{-1}$ (Hissein, 2020). Likewise, the calcium and magnesium contents in the literature are low: 4.8 and 5.0 mg/L respectively (Hoteyi *et al.*, 2014), 39.99 and 12.81 mg/L (Sahirou *et al.*, 2020). At Mont-Bouet market, the low values of sachet water in chloride, nitrate and phosphate ions (respectively 3.2, 4.1 and 2.9 mg/L on average) can be correlated with the low mineralization of water. These anions are often found in low levels in drinking water (Sahirou *et al.*, 2020).

Conclusion

The commercialization of sachet water at Mont-Bouet market is booming, probably because of its affordability and the difficulties people experience in accessing drinking. Though this activity constitutes an important source of income, it is often practiced illegally and

hygiene measures are not respected. This constitutes a health risk for the populations consuming it. Furthermore, the sachet water sold at Mont-Bouet market display unreliable information. As such, it contributes to calling into question the quality of the water sold. Regarding this situation, the competent services should carry out more controls and sensitizations in the sale of this drinking water.

Declaration of competing interest

The authors declare that there was no conflict of interest in the preparation of this article.

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