FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 4 No. 3, September, 2020, pp 178 – 184
DOI: https://doi.org/10.33003/fjs-2020-0403-359

EVALUATION OF SHELF LIFE OF SACHET WATER PRODUCED IN JOS NORTH, PLATEAU STATE

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ABSTRACT
Sachet water has gradually become the most widely consumed portable water for everyone in Nigeria. This study aimed to assess physiochemical and bacteriological properties of selected sachet water brands. Random sampling method was used to collect data from 20 selected brands within Jos North Metropolis, the 20 selected brands served as sampling frame where by 3 brands were selected for the pilot study. The three brands selected as pilot study were; FEDCOF, LOANE and MCEDEN. The samples of sachet water were collected from the 3 different brands within 24 hours of production which were transported to Bauchi State Water Board for analysis. The parameters were analyzed following standard procedures to determine the physical chemical and bacteriological content of the samples. The physiochemical properties of the samples were analyzed, it was observed that the following parameters: pH, Temperature, Turbidity, Total Dissolve Solid, Total Hardness, Conductivity, Alkalinity, Nitrate, Sulphate, Chloride and Iron were within the permissible limit, as compared to National Agency for Food and Drug, Administration Control and Standard Organization of Nigeria standards. Furthermore, bacteriological analysis was carried out on the three brands of sachet, remarkable presence of Faecal coli form count and total coliform count were detected and were though above the permissible limit set by NAFDAC and SON. It can be concluded that FEDCOF, LOANE and MCEDEN brands of Sachet in Jos North should not be consumed, when it has been kept beyond six (6) weeks, if consumed it may cause illnesses like typhoid fever, hepatitis, gastroenteritis and dysentery.

Keywords: Shelf life, bacteriological, physiochemical, sachet, water.

INTRODUCTION

An estimated 1.2 billion people around the world lack access to safe water, 80% of all disease and over 30% of deaths are related to drinking water; given the Federal Ministry of Health statistics, only 30% of Nigerians have access to potable water (Ojekunle *et al*., 2015). Rain, surface, and ground water are sources of portable in Nigeria. Similarly, Okeri *et al*., (2009) noted that most of the water consumed in Nigeria are obtained from rain water, lakes, rivers, springs, streams and ground water; others are boreholes and private wells, which do not always produce pure water due to various treatments before packaging and sale or use in other manufacturing process. In Nigeria, water is packaged in sealed nylons (sachet water). Sachet water is any water that is in sealed plastic and is distributed or offered for sale for human consumption (Oladipo *et al*., 2009). Most of the sachet water sold to the public is not wholesome, leading to water related diseases like diarrhea. Most people living in the major cities of Nigeria do not have access to pipe borne water, probably due to unavailability or inadequacy of portable water, people therefore, resort to the more costly alternative of buying water from vendors; hence, sachet water became a major source of drinking water (Omalu *et al*., 2010).

Sachet water is not completely sterile; it may not be entirely free from all infectious microorganisms. The potential danger associate with sachet water is contamination which is a factor of the source of water itself, treatment, packing materials and closure. Some of the total aerobic heterotrophic bacteria have been identified as opportunistic pathogens (Omalu *et al*., 2010).Water of good drinking quality is of basic importance to human physiology and mans continued existence depends very much on its availability. This fact accounts for why water is regarded as one of the most indispensable substances in life (Ojekunle *et al*., 2015). With the increase in consumption of sachet water in our communities today, there is a possibility of producing products that are not fit for human consumption because of monetary interests. Access to safe drinking water is still one of the major challenges of the 21st century. Unsafe water is a global public health threat, placing persons at risk for a host of diarrheal diseases as well as chemical intoxication. Sachet water can be contaminated with bacteria at various stages of production, under improper or prolonged storage of sachet water; bacteria can grow rapidly to the levels that may be harmful to human health (Omalu *et al*., 2010).

Sachet water has gradually become the most widely consumed liquid by both the rich and the poor in Nigeria. The perceived hygiene, purity, taste and safety are the reasons for the consumption of sachet water; the problem of its purity and health concerns has begun to manifest (Oladipo *et al*., 2009). The proliferation of industries producing sachet water in Nigeria is alarming. It's raises the question as to whether they are hygienically produced, but with the poor sanitary environment sachet water is produced, there is need for regulating agencies like the National Agency for Foods and Drugs Administration and Control (NAFDAC) and Standard organization of Nigeria (SON) to ensure that industries produce water under hygienic condition. Safe drinking water is essential to life and a satisfactory safe supply must be made available to consumers (Kalwale *et al*., 2012).

Water is one of the most important needs of all forms of life and

is unavoidable in man's daily life, constituting a sizeable percentage of man's daily food intake because human bodies do not have reserve supply (Anyamene and Ojiagu, 2014). It is also an essential requirement of life for drinking, domestic, industrial and agricultural uses (Isikwue and Chikezie, 2014). Quality water is colorless, tasteless, odourless, as well as free from faecal contamination (Opara and Nnodim, 2014). Sachet water sold to the public is supposed to be wholesome, unfortunately, the quality of water sold to the public in many places in Nigeria are not wholesome (Dibua and Ndianefo, 2007), if sachet water is kept and enclose for prolong period, it makes it unfit for potable use (Dibua and Ndionefo, 2007). The quality of pure water is still questionable, because many who are engaged in its production do not follow strictly the standard set by NAFDAC, WHO for safe drinking water (Ojekunle *et al*., 2005).

According to the NAFDAC, majority of sachet water are produced under questionable hygienic environmental conditions, without approval and does not meet standards (Zakaria, 2012). Regardless of all these problems associated with sachet water within Jos North Meropolis, it is still considered wholesome for drinking purposes as compared to river, well water and borehole, if the industrial standards are followed. The problems of the purity and health of sachet water concerns sometimes manifest after it has been stored for a lengthy period (Oladipo *et al.*, 2009). Some sachet water producers do not see the essence of proper storage and continually expose bagged sachet water to sunlight. There is also inadequate screening and monitoring of distributors, retailers, vendors, that sometimes compromise on quality of standards-complying products through improper handling, packaging, storage and distribution of sachet water within Jos North metropolis. Therefore, consumer confidence in the industry, which used to be very high, is gradually being eroded by these quality mishaps (Adam, 2014). Perhaps most disturbing of all is the health risks associated with these quality problems. The objective of this paper is to evaluate the physiochemical, bacteriological and shelf life of sachet water produce in Jos North LGA. The study will also help in sensitizing manufactures, vendors and the general public on the need to observed storage and the hazards associated with drinking such contaminated water.

The findings of this research would assist government policy on regulation of quality management in sachet water industry. It would enable monitoring agencies and other stakeholders realize the need for proper storage as a strategy to improve performance of the water producers in order to achieve the objective of ensuring safe and acceptable drinking water for the populace.

MATERIALS AND METHOD

Study Area

The study was conducted in Jos-North Local Government Area (LGA) of Plateau State, which is situated at the extreme North of the State and located between latitude 90 E55' North of the Greenwich meridian and longitude 80 E54' East of the Equator. It has an area of 291 km², making it the smallest LGA in Plateau State but with the largest population of 437,217, with 220,856 males and 216,361 females and having projected population of 621,315 in 2019 based on a growth rate of 2.74% (NPC, 2006).

The LGA shares boundaries to the North with Toro Local Government Area of Bauchi State; to the south with Jos-South Local Government Area; to the East with Jos-East Local Government Area; and to the West with Bassa Local Government Area of Plateau State. Although Jos-North is located in the tropical zone, the area however has a near temperate climate, with an average temperature of 18-27 ^{0}C, an altitude of 1,500 meters above sea level and an average annual rainfall of 1317.5 to 1500 mm per annum (Haruna *et al*., 2007).

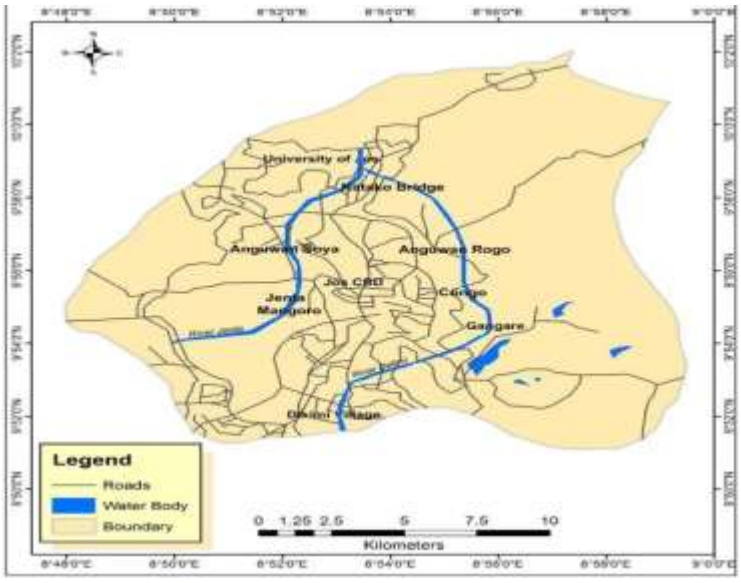

Figure 1: Map of study area

Sampling Techniques and Pilot Study

Simple random sampling method was used to select the brands of sachet water for the study. Lists of sachet water brands in Jos

North obtained were assigned numbers from 1-20 and this formed the sample frame of the sachet water brands. These numbers were then written on pieces of papers, folded and placed in a container. They were then mixed, shaken thoroughly and picked one after the other for three consecutive times. After each pick, the container was mixed and shaken again until the three numbers were obtained. The numbers were then traced to the appropriate sachet water brands. In all, three different brands of 50cl sachet water were selected for the study, as presented in Table 1.

Table 1: Sampling frame

S/N	BRANDS	NAFDAC NO
1	FEDCOF TABLE WATER	C1-1969L
2	MCEDEN TABLE WATER	01-1652L
3	STAR TABLE WATER	01-4707L
4	ELLACO TABLE WATER	B1-4310L
5	SKYSUN TABLE WATER	01-4059L
6	ABIBEK TABLE WATER	C1-9553L
7	CAMRIE TABLE WATER	A1-9042L
8	MUFEES TABLE WATER	C1-9040L
9	LOANE TABLE WATER	C1-0152L
10	KATURU TABLE WATER	D1-8732L
11	EMYWIT TABLE WATER	D1-5225L
12	DISCOVERY TABLE WATER	A1-5463L
13	GOLDCARE TABLE WATER	01-8717L
14	CANON TABLE WATER	01-1897L
15	TUNTURI TABLE WATER	A1-8348L
16	NA"IM TABLE WATER	D1-6611L
17	INGANCHI TABLE WATER	D1-7307
18	ZANEX TABLE WATER	D1-4846L
19	SMG TABLE WATER	D1-1267
20	ECWA TAABLE WATER	B1-1128

Pilot study was conducted with three (3) brands of sachet water which were randomly selected prior to the main study to ascertain the reliability of the laboratory apparatus to effectively measure their physio-chemical and microbiological parameters. These were FEDCOF table water, MCEDEN table water and LOANE table water. Table 1 shows 20 different factories from which the three brands under study were choosing using random sampling method. The samples of sachet water were collected directly from the factory in bags within 24hours of production and stored at room ambient temperature. The samples collected were sent to Bauchi State Water Board Laboratory for analysis. Fresh samples from the factory were labeled A, sample B (stored for 2weeks), sample C (stored for 4weeks), sample D (stored for 6weeks). Sub-samples were drawn from the stock packs in triplicates for physio-chemical characterization and bacteriological analysis using APHA analytical methods.

Analyses of Water Samples

The laboratory tests were conducted at the Bauchi State Water Board Laboratory. The samples were then store at room temperature of 20 -27˚C. In other to check for the quality of the water samples with respect to changes in the state of water that took place during storage. Some physiochemical and bacteriological analysis were conducted. The physiochemical analysis conducted were pH, turbidity, electrical conductivity, total dissolved solids (TDS), total hardness, total acidity & alkalinity nitrate, Sulphate, and iron.

Physio-Chemical Parameters

To determine the physio-chemical parameters, standard laboratory procedures where adopted to determine temperature, turbidity, pH, total Acidity and Alkalinity, electrical conductivity (EC), total hardness, total suspended solid, nitrate, Sulphate, iron, chloride, total coliform count and Faecal coliform count.

Statistical Analysis

All data generated were analyzed statistically by calculating the mean and comparing the mean value with the acceptable standards by NAFDAC and SON. The data collected were statistically analyzed using statistical package for social sciences (SPSS, version 20) and analysis of variance (ANOVA) and the least significant difference test was used to separate differences among the means.

RESULT AND DISCUSSION

The results obtained for the effect of pure water brand on the physio-chemical properties are presented in the Table 2. Results shows that all the physical and chemical parameters were within the permissible limit by NAFDAC and SON within six weeks when sachet water stored.

Table 2: The effect of pure water brands on physical parameters

Parameter	LOANE	FEDCOF	MCEDEN	NAFDAC/SON STANDARD(2015)	SEM

P^H	7.43	7.58	7.21	6.5 - 8.5	0.16
Temperature (^oC)	27.20	27.30	27.30	35 - 40	0.16
Conductivity (us/cm)	377.00a	142.67c	171.93b	1000	20.45
Total Dissolved Solid (mg/l)	185.33^a	71.00^c	86.03^b	500	9.95
Turbidy (NTU)	0.52^b	0.61^a	0.26^c	5	0.16
Alkalinity (mg/l)	66.33^a	61.00^c	62.00^b	100	0.53
Total Hardness (mg/l)	68.00^a	65.00^b	67.00^a	100	0.29
Chloride (mg/l)	1.31^a	0.20^{ab}	0.10^b	100	0.19
Nitrate (mg/l)	2.31	2.01	2.17	10	0.16
Sulphate (mg/l)	2.31	2.01	2.17	100	0.48
Iron (mg/l)	0	0	0	0.3	0.16
Faecal Coliform Count	1.67^b	4.00^a	2.67^b	0	0.51
Total Coliform Count	4.67^c	9.33^a	8.00^b	0	0.67

^{abcd} Means on the same column with different superscripts are significantly different ($p<0.05$)

The results obtained with respect to weeks for the three brands are presented in Table 3. It was observed that there were significant differences among the following parameters: Conductivity, total hardness of water, Faecal Coliform Count and Total Coliform Count. However, amongst all the parameters considered only the bacteriological parameters were above the permissible level.

Table 3: Interactions effect of pure water brands and weeks on physical parameters

Parameters	Weeks	LOANE	FEDCOF	MCEDEN	NAFDAC/SON STANDARD(2015)	SEM

P^{H}	2	7.4	7.6	7.1	6.5 - 8.5	0.29
	4	7.42	7.6	7.2		0.29
	6	7.47	7.6	7.24		0.29
	SEM	0.29	0.29	0.29		
Temperature (ºC)	2	27.2	27.3	27.3	35 - 40	0.29
	4	27.2	27.3	27.3		0.29
	6	27.2	27.3	27.3		0.29
	SEM	0.29	0.29	0.29		
Conductivity (us/cm)	2	370.00^{ai}	140.00^{bk}	170.00^{bj}	1000	37.58
	4	374.00^{bi}	142.00^{bk}	170.00^{bj}		36.56
	6	378.00^{ai}	146.00^{ak}	175.80^{aj}		36.44
	SEM	0.82	0.93	1.01		
Total Dissolved Solid (mg/l)	2	185	70	85	500	18.05S
	4	185	71	85		17.95
	6	186	72	88.1		17.81
	SEM	0.33	0.41	0.59		
Turbidity (NTU)	2	0.52	0.61	0.22	5	0.3
	4	0.52	0.61	0.28		0.29
	6	0.52	0.61	0.29		0.29
	SEM	0.29	0.29	0.29		
Alkalinity (mg/l)	2	65	60	61	100	0.88
	4	67	61	62		0.97
	6	67	62	64		0.78
	SEM	0.44	0.41	0.65		
Total Hardness (mg/l)	2	68.00^{ai}	65.00^{0}	67.00^{aij}	100	0.53
	4	68.00^{ai}	65.00^{aj}	67.00a^{ij}		0.53
	6	68.00^{ai}	65.00^{aj}	67.00^{aij}		0.53
	SEM	0.29	0.29	0.29		
Chloride (mg/l)	2	1.2	0.2	0.1	100	0.34
	4	1.32	0.2	0.1		0.35
	6	1.40	0.2	0.1		0.36
	SEM	0.29	0.29	0.29		
Nitrate (mg/l)	2	2.15	2	2.02	10	0.29
	4	2.21	2.01	2.22		0.29
	6	2.57	2.02	2.27		0.3
	SEM	0.3	0.29	0.29		
Sulphate (mg/l)	2	17	17	13	100	0.73
	4	18	17	13		0.93
	6	19	17	13		0.93
	SEM	0.44	0.29	0.29		
Iron(mg/l)	2	0	0	0	0.3	0
	4	0	0	0		0
	6	0	0	0		0
	SEM	0	0	0		0
Faecal Coliform Count	2	0.00^{bi}	1.00^{bi}	2.00^{ai}	0	0.41
	4	1.00^{bi}	2.00^{bi}	3.00^{ai}		0.41
	6	4.00^{aj}	9.00^{ai}	3.00^{aj}		0.97
	SEM	0.67	1.29	0.33		
Total Coliform Count	2	2.00^{bK}	5.00^{ai}	6.00^{bj}	0	1.2
	4	3.00^{cj}	11.00^{bi}	8.00^{abi}		0.91
	6	9.00^{aj}	12.00^{ai}	10.00^{aij}		0.53
	SEM	1.13	1.13	0.65		

^{abcd} Means on the same column with different superscripts are significantly different ($p<0.05$)
^{ijklm}Means on the same row with different superscripts are significantly different ($p<0.05$)

DISCUSSION

pH

The data obtained from as presented in Table 2 shows that the pH mean concentration ranged from 7.21-7.58, it was observed to be within permissible limit recommended by NAFDAC and SON Standards. The variation in the P^H mean values for the three brands shows no significant difference ($p < 0.05$) among the brands and weeks of storage as presented in Table 3. Oladipo *et al*., (2009) reported similar research with the P^H value ranged from 4.43-7.71 which was slightly lower than the value obtained in this research which may be due to differences in the source of water. However, water with high pH has been reported to reduce blood viscosity, this may help reduce cardiovascular strain due to dehydration.

Temperature

Table 2 indicates that the mean value of temperature for the three brands ranged from 27.20-27.30 and this was discovered to be within the permissible limit recommended by NAFDAC and SON. Therefore, the results indicate that there is no significant difference at (P>0.5) among the three brands and weeks of storage as presented in Table 3. Ojekunle *et al*., (2015) reported similar result, but the temperature was higher than the value obtained in this research which may be due to climatic differences.

Turbidity

The turbidity mean value for the three brands were discovered to be within the permissible limit by NAFDAC and SON standards and also the results shows no significance difference at (P>0.05) for the three brands and the weeks of storage as presented in Table 2 and 3.

Turbidity occurs as a result of the pressure of suspended material which could be industrial waters, agricultural wastes, microbial growth, erosion products, and presence of human organs which will result to some disease. Joshua *et al.*, (2014) posited that turbidity does not have a health based guideline but it is recommended that it should be ideally below 1.0 NTU for effective disinfection.

Electrical Conductivity

The data captured in Table 2 indicates that the mean value of electrical conductivity (EC) were within the permissible limit recommended by NAFDAC and SON standards (2015) and the results also indicates that the mean value of EC shows significance difference at (P>0.05) among the brands and the weeks of storage as presented in Table 3. Uduma, (2014) obtained conductivity value ranged from 375-680 mg/l which was higher than the ranged obtained in this research; differences may be due to water source or during production and storage period.

Total Dissolve Solute

The results obtained from this research indicates that the water samples analyzed from the three factories were within the permissible limit recommended by NAFDAC and SON (2015) and there was no significance difference at (P>0.05) among the brands and the weeks of storage. The portability of water with TDS level of less than about 500 mg/l is generally considered to be good, whereas drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/L. (Hussain *et al.,* 2010) also observed that the presence of solids in sachet water may be as a result of poor filtration methods. High value of TDS in water is generally not harmful to human beings, but in high concentration of these may affect persons who are suffering from kidney and heart diseases. Water containing high solid may cause laxative or constipation effects, (Harunae*t al*., 2002).

Alkalinity

The data represented in Table 2 indicates that the mean values of alkalinity were within the permissible limit recommended by NAFDAC and SON Standard. There was no significance difference (P>0.05) among the brands and the weeks of storage as presented in Table 3, however for irrigation purposes, irrigation water between 30 and 60 ppm are considered optimum for most plants (Hussain *et al.,* 2010).

Total Hardness

The results shows that the three brands as presented in Table 2 and 3 indicates that the mean value of total hardness were within the permissible limits recommended by NAFDAC and SON. The results also shows significance difference at (P>0.05) for the three brands and the weeks of storage. Total hardness in natural water is mainly due to the presence of calcium and magnesium salts and bicarbonate formed by reactions in the soil and rock through which the water percolates.

Chloride

The mean values of this analysis recorded as presented in Table 3 indicates that the values were within the permissible limits as recommended by NAFDAC and SON. The result also shows a significance deference at (P>0.05) among the brands and the weeks of storage. The differences among the brands may be due to differences in the source of water for production.

Chloride toxicity has not been observed in human except in the special case of impaired sodium chloride metabolism, e.g. in congestive heart failure. Healthy individuals can tolerate the intake of large quantities of chloride provided that there is a concomitant intake of fresh water (Bukar *et al.,* 2015).

Nitrate

The results obtained from water analysis were within the permissible limit recommended by NAFDAC and SON as presented in Table 2 and 3. The result also indicate that there is no significance difference at (P>0.05) among the brands and the weeks of storage. Bukar *et al.,* (2015) reported similar research with nitrate concentration range from 1.42-4.97 mg/l but the value recorded was lower than the value obtained in this research, the differences may be due to location of water source. Nitrate accumulation in plants is a subject of concern for human and animal health, as edible part may contain very high concentrations of this ion that has been implicated in the occurrence of methaemoglobinemia and possibly in gastric cancer (Bukar *et al.,* 2015).

Sulphate

The results obtained from the analysis as presented in Table 2 and 3, it shows that the mean value of Sulphate were within the permissible limits as recommended by NAFDAC and SON standards. There was no significance difference at (P>0.05) among the brands and the weeks of storage. Bukar *et al.,* (2015) reported similar research but the value obtained was 0.3 mg/l which is lower than the value of 2.17-2.31 obtained in this

research, though they are all within the permissible limit set by NAFDAC and SON and it may not be harmful for human health. Sulfate concentration in natural water ranges from a few to a several 100mg/l, but no major negative impact of sulfate on human health is reported.

Iron

The data shown in Table 2 and 3 for water analysis indicates that the mean values of Iron were within the permissible limit as recommended by NAFDAC and SON. The result also indicate that that there was no significance difference at (P>0.05). Iron plays an important role in respiration, photosynthesis and the production of healthy green leaves. In crops, and especially in those grown on calcareous soils, iron deficiency is a major nutritional disorder that causes decrease in vegetative growth and marked yield and quality losses.

Total and Faecal Coliform Count

The result of this analysis captured in Table 2 and 3 indicates that the mean values of faecal coliform count were considered above the recommended limits by NAFDAC and SON. There was significance difference at (P>0.5) for the three brands. Heterotrophic count (HPC) measures a range of bacteria that are naturally present in the environment. Bukar *et al.,* (2015) in their research in Zaria reported the presence of E.coli or coliform counts up to 58 cfc/100ml which is much higher than the value obtained in this research. The presence of coliforms in portable water is used as indicator of water contamination. Although coliforms are generally not harmful, they indicate the presence of pathogenic bacteria, viruses and protozoa.

The results obtained from analyzed water samples within the periods of study as presented in Table 3 indicates the presence of bacteria among the brands and weeks interaction because the values recorded were above the recommended limits by NAFDAC and SON. There was significant difference at (P>0.05) among brands. Diseases and illnesses that can be contracted in water with high fecal coliform counts include; typhoid fever, hepatitis, gastroenteritis, dysentery and ear infections.

CONCLUSION

The outcome of this research shows that the parameters analyzed were within permissible limit by NAFDAC and SON except total coliform count and Faecal coliform count which shows the presence of bacteria in three brands selected .It is all evident that all the values of pH, Temperature, Turbidity, Total Dissolve Solid, Total Hardness, Conductivity, Alkalinity, Nitrate, Sulphate, Chloride and Iron fall under the permissible limit and therefore having no effect on human health.

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