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Effect of Storage on the Quality of Sachet Water Consumed by Households in Nsukka Zone

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Abstract

The purpose of this study was to investigate the effect of storage on the quality of sachet water consumed by households in Nsukka zone of Enugu State. Two Research Questions guided the study. Experimental design was used. Four brands of sachet water were randomly selected by balloting from seventeen brands of sachet water identified in the zone. The duration and storage environment included day one as the control, 2 weeks, 5 weeks and 8 weeks and refrigeration and outdoor storage environment. The sensory and microbial evaluations were conducted using 9- point hedonic rating scale and multiple number counts (MPN). The findings indicated that all brands of sachet water had *E.coli* at day one. Refrigerated water had the best taste and odour at 2 weeks and very minute microbial content at 8week of storage. It was recommended that, for the safety of sachet water consumers, the storage duration should not exceed fourteen (14) days of production.

Keywords: Storage, Quality, Sachet, water, Packaged

Introduction

Water is a clear, colorless, tasteless and odourless liquid, which is very important to both plants and animals. It is a simple substance containing two atoms of hydrogen and one atom of oxygen (H_2O). Though, it has no calorific value, still everybody cell, tissues, organs and all life sustaining body process needs water to function. Ekairia and Iroanya, (2005) noted that water is critical for the sustenance of human life and a vital constituent of all forms of life. It occupies about 70% of the earth's surface. Water, according to World Health Organization (WHO 2003) is a basic nutrient of the human body and is critical to human life. Without water, life cannot be sustained beyond a few days. Okeke (2009) also observed that water is a vital constituent of the body, forming about 72% of fat free weight, is a medium in which virtually all body processes take place. It is a neutral substance that permits ionization of most materials.

Water is essential to sustain life. A satisfactory (adequate, safe, and accessible) supply must be available to all as it helps in maintaining the normal physiological activities of the body such as enzymatic and chemical reactions, lubrication of joints, regulation of hometasis and body weight, proper functioning of cells and tissues as well as some therapeutic values (Onigbinde, 2005). Improving access to safe or potable drinking water can therefore result in tangible benefits to health (WHO, 2004). Nwachukwu and Emeruem (2007) noted that potable water is a transparent liquid without colour, taste or odour, but when infected with organisms, loose its qualities and instead becomes harmful to both human and animal populations. Water Quality, according to Ekpo and Eddy (2005) refers to those chemical, physical and biological characteristics, by which the user evaluates the acceptability of the water. WHO (2000) advanced some standard for quality of drinking water and its safety. This standard for potable drinking water borders on microbial factors as: total coliform of 100ml should be zero; *E.coli* of CPU/100ml is zero; *Streptococcus Faecalis* of 50ml is zero; Total plate count of CPU/100ml is zero (WHO 2006). Standard Organization of Nigeria (SON 2003) also has its standard on packaged and unpackaged water as:

coliform is nil; *E.coli* is nil; *Faecalis Streptococci* is nil; Spore of sulphide –reducing *clostridia* is also nil.

Packaged water also called sachet water is one of the local interventions to make drinking water accessible to rural and urban populace. It is widely available in both developed and developing countries (Dada, 2008). Nwachukwu and Emeruem (2007) defined sachet or packaged water as any water that is in sealed plastic, distributed or offered for sale for human consumption. Bennie (2007) stated that the plastic in which the water is packaged for the market contained micro pores which rendered it susceptible to the invasion of micro organisms when exposed to the sun. Water, if kept enclosed for a prolong period allows anaerobic algae and other microbes to grow in it making the water unsafe and unfit for potable use (Adofo, 2009).

Method of storage of a product impacts not only its quality, but also its safety. According to Egwari and Aboaba, (2002), sachet water is unreliable. The quality of 'Pure water' is still questionable because many who are engaged in its production do not follow strictly the standards set by National Agency for Food, Drug Administration and Control (NAFDAC), WHO and SON for safe drinking water (Okpako, Osuagwu, Duke and Ntui (2008). Bennie also explained that, sachet water as a product has specific temperature conditions under which it must be kept and failure to do so can cause serious health problems. Water is one of the vehicles for transmission of pathogenic organisms (Ejima, 2005). The National Health Management Information System Enugu State (2010 unpublished) stated that an approximate of 30,815 patients was affected of different types of water borne diseases in the zone from

January to July 2010. To determine the effect of storage on a product, the product is exposed to a controlled environment in which one or more storage conditions such as temperature, humidity, atmosphere, or light are maintained at a higher than normal level, resulting in a shorter than normal time for product failure (Giese, 2000). Sachet water is one of the sources of drinking water for the people of Nsukka zone, hence the need to study, the effect of storage on the quality of sachet water. The findings of this study will be of immense benefit to humanity, most especially to parents, children, home makers, teachers of home economics, community members, students and the entire populace of the nation, as this will provide them with information that will help them in the storage or keeping of sachet water.

Purpose of the Study

The major purpose of the study was to investigate the effect of storage on the quality of various sachet water consumed by households in Nsukka zone. Specifically, the study sought to:

1. determine the effect of storage on odour and taste of the four brands of sachet water, consumed by households in Nsukka zone.
2. identify the effect of handling practice on the microbial content of the four brands of sachet water, consumed by households in Nsukka zone.

Research Questions

The study sought answers to the following research questions

1. What is the effect of storage on the odour and taste of the four brands of sachet water, consumed by households in Nsukka zone?
2. What is the effect of handling on the micro-organisms content of the four brands of sachet water, consumed by households in Nsukka zone?

Methodology

***Area of the study*:** The study was carried out in Nsukka zone of Enugu state of Nigeria. Four brands of sachet water were used for the study, which include MC table water, Jives table water, De Occasion table water, Ecaison table water.

***Design of the study*:** The study was conducted using experimental research design which involves both sensory evaluation and laboratory-based in-vitro studies. This Laboratory-Based In-vitro Studies enables the researcher to examine the presence of specific variables (micro organisms: coliform and mould) in the sachet water samples using reagents under controlled environment. Also the study made use of sensory evaluation to carry out the sensory test such as taste and odour which cannot be carried out in the laboratory.

***Population for the study*:** The population of the study involved the seventeen (17) brands of sachet water identified in the zone. The water brands include MC table water, Jives table water, De Occasion table water, Ecaison table water, Lion table water, Assured table water. Aqua Rapha table water, Ngene table water, Trans table water,

O'gala table water, Kachel table water, Zeroth table water, Mount Calvary table water, Fidema table water, Pat Blessed table water, Rock Tama table water, and Add More table water. Aqua Rapha table water, Ngene table water, Trans table water, and zeroth table water are produced outside the zone, while all others are produced within the zone. The four brands of sachet water selected from the seventeen (17) brands include: MC table water, Jives table water, De Occasion table water and Ecaison table water. These brands were coded MCW, JIW, DOW, ETW.

***Sample for the study*:** A random sampling technique was used to select four brands of sachet water and this was done by balloting from the seventeen brands of sachet water available in the zone. Fourty-two (42) samples of sachet water were collected from each of the four brands selected for the experiment, bringing the samples to one hundred and sixty-eight (168) samples.

***Instrument for data collection*:** The following instruments were used for data collection. For the physical properties, odour and taste were observed through sensory evaluation by a ten (10) man trained panel using 9-point hedonic scale rating score sheet.

A 9- point hedonic rating scale was formulated in two categories for odour and taste as follows:

Taste

Tasteless 9; Slightly tasty 8; Moderately tasty 7; Very tasty 6; Extremely tasty 5; Slightly sour 4; Moderately sour 3; Very sour 2; Extremely sour 1.

Odour

Odourless 9; Slightly pleasing 8; Moderately Pleasing 7; Very pleasing 6; Extremely Pleasing 5; Slightly offensive 4; Moderately offensive 3; Very offensive 2; Extremely offensive 1;

B. The microbial properties were done using the most probable number (MPN) count of coliform organisms in samples. The MPN procedure is a multiple-tube dilution method using nutrient-rich media which is applicable to all types of microbiological organisms. The organisms looked out for were: Coliform test (*E.coli*), Mould count (f*ungi*). In this MPN method the examination starts with the presumptive *coliform* test, in which measured volumes (10ml or more) of the samples are inoculated into a series of five or more tubes containing a suitable liquid differential medium of lactose. After incubation for 37^{o}C for an appropriate time of 48hours, the tubes are examined for acid and / or gas production. The presence of acid or gas indicates positive reaction caused by some other organism or combination of organisms. The presumption that the positive reaction is caused by *coliform* organisms will therefore be confirmed by additional test with differential media, incubating at a temperature of 35-44^{o}C for 48hours.

***Data collection Technique*:** The twenty-four (24) water samples were initially tested for control (A) and then the rest (144) water samples were divided into two storage environments namely: (i) outdoor (that is kept at the corridor); (ii) refrigerating storage. Subsequently, the

water samples from the various storage environments were tested at 2weeks (B); 5weeks (C) and 8weeks (D) formed the experimental group. Forty-eight (48) samples (6 each from the four brands) from the two storage environments are used at each experimental period for both sensory and microbiological examination.

For the sensory evaluation: Thirty-two (32) samples (4 each from the four brands) from the two storage environments are used at each experimental period for the sensory examination by the ten (10) man panel using the 9- point hedonic rating scale designed above.

***For microbial evaluation*:** The microbiological examination of water was conducted on Coliform *(E.coli*) and Mould organisms in the samples. The MPN procedure used is a multiple- tube dilution method using nutrient rich media and the media used are MacConkey Agar and Ssbourand 4% Glucose Agar.

Media Preparation for coliform and total viable count determination

Sabourand Agar Preparation: Sabourand 4% Glucose Agar was prepared according to the manufacturer's prescription, which says 65g of Sabourand glucose agar should be added to 1litre of distilled water. Since 40mls of the agar media is to used for each sample of water, therefore 40mls x 12samples = 480mls of media.

- Thus 32.5g Sabourand glucose agar was added to 500ml of distilled water.
- Then the media was put into the autoclave to heat to a temperature of 121^{o}c and then allowed to remain in the autoclave for 15minutes.
- Then the media is allowed to cool (warm state).

For colform determination:

Coliform determination was done using 40ml prepared sabour and agar and 0.1ml of water sample was poured into a petri dish and then incubated at 37^{o}c for 24 hrs and then, the colonies were counted on completion of the incubation period. This was done for the four brands of water samples at the experimental period.

Media Preparation for mould count determination

MacConkey Agar Preparation: Mac Conkey agar was also prepared according to the manufacturer's prescription, which says 52g of Mac Conkey agar should be added to 1litre of distilled water. Since 40mls of the agar media will be used for each sample of water, therefore 40mls x 12samples = 480mls of media.

- Thus 26g of Mac Conkey agar was added to 500ml of distilled water.
- Then, the media was put into the autoclave to heat to a temperature of 121^{o}c and then allowed to remain in the autoclave for 15minutes.
- Then the media is allowed to cool (warm state).

For mould (fungi) determination:

The mould determination was also done using 40ml prepared MacConkey agar media and 0.1ml of water sample was

poured into a Petri dish and then incubated at 35oc for 48hrs in an incubator. The colonies were counted on completion of the incubation period. This was also done for the four brands of water samples at the experimental period.

Data Analysis Technique: Mean was used for answering research questions 1 and 2. The mean of the data was compared using Least Significance Difference (LSD) at 0.05 level of significant. Mean was expressed as Mean ±SD, where SD is the standard deviation.

Findings

The following findings were made

1. Effect of storage on odour and taste of the four brands of sachet water is as follows in table 1 and 2.

Table 1: Sensory Evaluation Scores on Effect of Storage on odour (Hedonic Scale) of Sachet water

Storage methods	Time	Brands MCW	JIW	DOW	ETW
Outdoor	A	6.9±2.13	7.5±2.42*b	7.2±1.93c	7.9±1.66d
	B	6.3±2.16	7.8±1.81*b	6.4±3.03c	6.2±2.78
	C	6.0±2.31	6.8±2.30b	6.1±2.56c	6.7±1.83
	D	5.9±1.73	5.5±1.96*b	5.4±2.37c	5.8±1.75*d
Refrigeration	A	6.9±2.13a	7.5±2.42	7.2±1.93	7.9±1.66
	B	8.2±1.23*	7.9±1.66	8.2±1.62	8.3±0.82
	C	3.8±2.44*	3.8± 2.04*	3.7±1.83*	3.4±2.68*
	D	2.4±2.07*	1.8±1.23*	1.6±0.97*	1.7±0.95*

*. The mean difference is significant at the 0.05 level; MCW= M.C water; JIW = Jives table water; DOW= De Occasion table water; ETW= Ecaison table water

Table 1 shows that there were significant differences ($p<0.05$) between the odour of ETW and JIW at A and D, B and D in JIW only. No significant difference ($p<0.05$) was shown in table 1 between the odour of DOW when stored at the four specified durations outdoor. In the refrigerated samples, there were also significant differences ($p<0.05$) between the odour of MCW at A and C, A and D, B and C, and B and D. For the other brands of water sampled, there was no significant difference ($p<0.05$) only between A and B at refrigerating storage environment.

Table 2: Sensory Evaluation Scores on Effect of Storage on Taste (Hedonic Scale) of Sachet water

Storage environment	Time duration	Brand MCW	JIW	DOW	ETW
Outdoor	A	7.4±1.65[a]	7.8±1.55[b]	7.9±0.99[c]	7.9±0.88[d]
	B	6.7±1.64[a]	7.7±0.95*[b]	7.1±0.99[c]	7.3±1.56[d]
	C	6.4±1.27[a]	6.6±1.17*[b]	6.3±2.06*[c]	6.7±1.34[d]

	D	6.3±1.34[a]	5.2±1.75*[b]	5.9±1.73*[c]	5.8±1.69*[d]
Refrigeration	A	7.4±1.65	7.8±1.55	7.9±0.99	7.9±0.88
	B	6.9±1.97	7.5±0.97	7.1±2.02	7.9±0.99
	C	4.6±1.90*	5.7± 1.95*	5.5±2.17*	4.5±2.75*
	D	3.0±1.41*	2.9±1.66*	2.9±1.79*	2.7±1.83*

* The mean difference is significant at the 0.05 level. MCW – Mc table water, JIW – jives table water, DOW – De occasion table water, and ETW – Ecaison table water.

Table 2: No significant difference ($p<0.05$) was observed in Table 2 between the taste of MCW samples stored outdoor at the four specified time duration. There were significant differences in the taste of JIW and ETW stored for A and D, B and D, and C and D in JIW only. Significant differences ($p<0.05$) were only observed between the taste of DOW stored for A and C, 3. :

and A and D at outdoor. For all the brands in refrigeration in **table 2**, the tastes of the water were slightly bad in the C and D of storage, and for all the brands sampled only water stored for A and B showed no significant difference ($p<0.05$) in taste.

2. Effect of storage on micro-organisms are as follow in tables 3 and 4 below

T**able 3: Effect of Storage on micro-organism (COLIFORM) Count**

Storage Environment	Time duration	Brand MCW	JIW	DOW	ETW
Outdoor	A	6.0±0.00[a]	6.0±2.83b	5.0±0.00c	4.0±2.83d
	B	8.0±0.00[a]	14.0±0.83*b	12.0± 0.00*c	14.0±0.00*d
	C	12.0±0.00*[a]	19.0±1.41*b	20.0±0.00*c	16.0±2.83*d
	D	34.0±2.83*[a]	32.0±0.00*b	22.0±0.00*c	28.0±2.83*d
Refrigeration	A	6.0±0.00*	6.0±0.00*	5.0±0.00*	14.0±0.00*
	B	0.0±0.00[a]	0.0±0.00[b]	0.0± 0.00[c]	0.0±0.00[d]
	C	2.0±0.00*	7.0±0.00*	0.0±0.00[c]	3.0±1.41*
	D	5.0±1.41*	16.0±0.00*	7.0±1.41*	7.0±0.00*

*The mean difference is Significance at 0.05 level. MCW – Mc table water, JIW – jives table water, DOW – De occasion table water, ETW – Ecaison table water.

Table 3: There were significant difference ($p<0.05$) in the mean coliform values of MCW, JIW and ETW at A, C and D of outdoor storage **in table 3**, while significant differences ($p<0.05$) were noticed in DOW at all the storage time except for C and D in outdoor. Significant differences at ($p<0.05$) were also observed in table 3 in the mean *coliform* of MCW, JIW, DOW and ETW stored for A, B, C and D respectively at the refrigerating environment.

Table 4: Effect of Storage on micro-organisms (MOULD) of Sachet water

Storage Environment	Time duration	Brand MCW	JIW	DOW	ETW
Outdoor	A	0.0±0.00[a]	0.0±0.00[b]	0.0±0.00[c]	0.0±0.00[d]
	B	0.0±0.00[a]	3.0±0.00[b]	6.0± 1.41[c]	0.0±0.00[d]
	C	12.0±5.66*[a]	12.0±0.00*[b]	16.0±2.83*[c]	0.0±0.00[d]
	D	16.0±2.83*[a]	14.0±2.83*[b]	20.0±0.00*[c]	6.0±2.83*[d]
Refrigeration	A	0.0±0.00[a]	0.0±0.00[b]	0.0±0.00[c]	0.0±0.00[d]
	B	0.0±0.00[a]	0.0±0.00[b]	2.0± 0.00*	0.0±0.00[d]
	C	6.0±2.83*	0.0±0.00[b]	4.0±1.41*	0.0±0.00[d]
	D	7.5±0.70*	2.0±1.41*	8.0±1.41*	10.0±2.83*

*. The mean difference is significant at the 0.05 level. MCW – Mc table water, JIW – jives table water, DOW – De occasion table water and ETW – Ecaison table water.

Table 4: All the brands of water sampled and stored outdoor showed no mould count at day one in table 4. No significant differences were observed between the mould count of JIW and DOW at A and B, and C and D respectively in table 4, while MCW had significant difference between mean mould count on A, C, and D of outdoor storage. ETW had no mould count until the eight week of outdoor storage. No mould count was observed in A for all the brands of water sampled and stored in refrigerating environment. At B of storage in Table 4, mould count was only observed in DOW and the number doubled as the storage time increased. For MCW, mould growth was observed from C of storage and this increased slightly in the D of storage. JIW and ETW had mould growth only at the D of storage in refrigeration.

Discussion

In outdoor samples, the odour of water sampled was observed to have deteriorated moderately, at eight weeks of storage in all the four brands of sachet water. When outdoor mean values were compared with refrigeration mean values. It was also observed that, at the first two weeks, the water was still very good, but at five weeks the water samples had slightly deteriorated, while at eight weeks it became moderately deteriorated, which agreed with Bennie (2007) that, the plastic in which the water is packaged for the market contained micro pores which rendered it susceptible to the invasion of micro organisms. Each water brand at 8weeks rated very low indicating that the odour of the water samples had deteriorated. Likewise the outdoor samples experienced tremendous decrease in taste in all the brands of the four sachet water, because at eight weeks the taste of water samples had deteriorated. This observation agreed with Giese (2000) who noted that small temperature change can have large effects on product keeping quality. When the mean values of outdoor storage were compared with mean values of refrigeration environment, it was observed to be similar to odour, which all the brands had deteriorated in taste at 5wks of storage. This observation agreed with

Okeke (2009), who noted that long term storage is best achieved by cooling at constant temperature. This revealed why the sachet water samples in refrigeration environment were bad at five weeks of storage.

All brands of water sampled had coliform from day one. This result corresponded with the study conducted by Dibua, Esimone and Ndianefo (2007) which noted that the bacteriological indices of contamination detected from the majority of sachet water samples are neither indication that the 'pure water' available in the university environment do not meet the NAFDAC (2004) nor the WHO (2003) standard and so may not be suitable for drinking purposes. Coliform count also showed progressive increase in all brands in outdoor storage. On comparison of the two storage environments, it was noticed that all brands of water sampled in refrigeration environment had a very low coliform count at eight week of storage.

With the mould count, all brands of water sampled as control were free of mould contamination at day one (A). However, as the storage duration continued *cladosporium sphaerosperum spp, curvularia lunata spp*, and *cladosporium macrocarpum spp.* were found in the two storage environments of the sampled water brands. Thus, comparing the two storage environments, it was noted that refrigeration environment had the least mould infestation at four specified time duration. The involvement of mould in this water samples may have occurred as a result of long keeping time, which agreed with Adofo (2009), that water kept enclosed for a prolonged period allows anaerobic algae and other microbes to grow in it, thereby making it unsafe and unfit for potable use. Similarly, Wright (2009) also stated that, it is only when a product is kept at a constant temperature that has no extremely highs or lows, that would keep its quality. Swiss Association for Nutrition (2009) also opined that, refrigeration occurs at temperature between -1^{o}C to + 8^{o} C, reactions leading to product spoilage are slowed down under refrigerating temperature and microbial proliferation is reduced. Finally, Weaser (2010) noted that fridges contain hydrofluorocarbon (HFC) gases as coolants and gases such as chlorofluorocarbons escapes to the environment in normal use and maintenance of fridges and these gases depletes the ozone layer. If these gases can deplete the ozone layer gradually, it then means, that the gases can react with any biological product in the fridge, thereby affecting its organoleptic and physical characteristics when kept for prolong period.

Conclusion

The analysis of result showed that at $p<0.05$, refrigeration environment had significant effect on microbial content, and at 2weeks taste and odour over outdoor storage in all the brands of sachet water considered in this study. Refrigeration environment had greater advantage over outdoor in micro-organisms content of the four brands of sachet water at three specified time durations. However, outdoor also had

advantage over refrigerating in terms of odour and taste at two specified time durations (5weeks and 8weeks) respectively.

Recommendation

- For the safety of sachet water consumers, the storage duration should not exceed fourteen (14) days of production at all levels of storage.
- Home Economics programmes with particular reference to Foods and Nutrition Curriculum should incorporate the ideal storage practices of sachet water into the secondary school curriculum. This is because water is food and needs all the attentions required to keep it safe for consumption in order to avoid contamination.
- Ideal storage practices should be taught to the people concerned with sachet water production, distribution and consumption in the zone and the nation at large. This can be done by organizing seminars and workshops to both sachet water producers, distributors and consumers on the ethics of production, best ways of storage (having a well ventilated warehouse and not under the sun or just any space outside the factor by producers and distributors)
- Research on Home Economics Education (especially Foods and Nutrition) should also focus attention on water storage and consumption, as water borne diseases are transmitted through the consumption and utilization of water in the home. This happen when contaminated water is taken or used for bathing and other domestic chores.

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