Comparative analysis of the association of some physical variables between commercially Available and home-produced oral rehydration solution samples

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Diarrheal is a child killer disease which is capable of causing a great loss of volume of fluid and electrolytes when it occurs. It is therefore necessary to secure a mechanism of replacing the lost fluid from a diarrheal impaired person, whenever it occurs. This study is therefore sought to measure the values of some variables of commercially available and home-produced oral rehydration solution samples, investigated within the temperature range of 0 to 60°C. The physicochemical variables investigated in this study include viscosity, pH, electrical conductivity, electric potential and total dissolved solid (TDS). The viscosity measurements were carried out by means of U-TUBE ASTM D-445 viscometer within the temperature range in this study. The pH and electrical potential values were obtained using pH/Electric Potential (mV) meter SUNTEX SP-701 and electrical conductivity meter, HACH CO-150 was used to measure the electrical conductivity of the samples of oral rehydration solutions from which, the values of the total dissolved solid were calculated. The results obtained reveal that there were significant differences in the measured viscosity and electrical conductivity of the samples at the temperature range of investigation in this study, with the viscosity ranging from 0.52±0.01 to 1.48±0.01 and 0.76±0.01 to 1.52±0.01 mPas for HPORS and CPORS, respectively and electrical conductivity ranging from 5.28 to 13.26 and 2.03 to 9.01 mS/cm for HPORS and CPORS, respectively. The total dissolved solid was observed to be greatly dependent on the electrical conductivity of the samples and the effect of temperature on pH of the samples was quite spelt out. The activation energy values for the samples were estimated from the viscosity measurements as 7.51 kJ mol^{-1} for the commercially available oral rehydration solution and 7.48 kJ mol^{-1} for the home-produced oral rehydration solution using the activation energy equation of Arrhenius. The high electrical conductivity of the home-produced rehydration solution could be indicative of low quality due to the quality of the salt and water used to prepare the ORS sample.

Key words: Diarrheal, oral rehydration solution, viscosity, electrical conductivity, electric potential.

INTRODUCTION

Diarrheal is a child killer disease which has been identified as being embedded with the potential of bringing about death among young children especially in the developing countries (Jonathan, 2020; Umeh and Ofoefule, 2013). This child killer disease is mostly pronounced in children between the ages of 1-5 years old as a result of severe dehydration. The disease of diarrheal can be brought about by viruses, bacteria or parasites which when occurs, potentially results into dehydration in the affected children and if not checked on time can result into death of the subject (Umeh and Ofoefule, 2013). Many cases of hospitalization and some of which have resulted into mortality in many developed as well as developing countries around the world have routes traceable to dehydration resulting from diarrheal. Kurt et al. (2019) opined that to eliminate this kind of disease requires large financial burden as its prevention is largely dependent on proper hygiene and sanitation coupled with the availability of supply of safe or clean water. Based upon reports of several researchers around the world, the effect of diarrheal as a child killer disease cannot be overemphasized. For instance, more than two million children die yearly due to dehydration resulting from diarrheal (Umeh and Ofoefule, 2013; King et al., 2003). As a result of the large volume of fluid and electrolytes lost during the event of diarrheal, it is necessary to secure a mechanism of replacing the lost fluid from a diarrheal impaired person, whenever it occurs. One solution that was recommended for this purpose by the World Health Organization (WHO) is oral rehydration solution (ORS) (Binder, 2019; Kurt et al., 2019). A major advantage of ORS is that it immediately reverses the dehydration process in a patient suffering from diarrheal as it restores the lost energy in the patient. Another advantage of ORS is that it can be supplied in large amount to places which lack access to clean water (Kurt et al., 2019). However, poor access to supplies of safe water, poor attitude towards its use and strict adherence to the practice of culture are some of the disadvantages of ORS. Also, there are situations in some countries where poor access to finance poses a barrier even though packets of ORS may be available (Umeh and Ofoefule, 2013; Kenji et al., 2012). ORS is a unique but simple salt and sugar solution prepared and given to a patient who is suffering from dehydration caused by diarrheal to take through the mouth in order for the immediate correction of the imbalance electrolytes and the replacement of fluid lost by the patient during the period of the diarrheal and also to prevent it from further occurring (Sollanek et al., 2019; Nicastro et al., 2018; Christine et al., 2007; WHO, 2001). The practice of the use of oral rehydration solution in the treatment of diarrheal and other diseases related with it is known as oral rehydration therapy (ORT). This practice started many years ago as recommended by scientists (Nalin and Cash, 2018; Pantenburg et al., 2012). A major advantage of ORT has to do with the fact that qualified mothers or any available adult can administer it (Umeh and Ofoefule, 2013). Diarrheal is a measure threat to our society, causing dehydration problem to the affected patients. This study therefore sought to measure the viscosity, pH, electrical conductivity and electric potential of commercially produced oral rehydration solution (CPORS) and home-produced oral rehydration solution (HPORS) samples so as to check for any significant differences in the values obtained for the purpose of comparison and quality assessment of the samples.

MATERIALS AND METHODS

One sachet of oral rehydration salt was purchased from a registered pharmaceutical shop in Benin City, Edo State, Nigeria. This was dissolved in 1 L of distilled water to prepare the Commercial ORS while dry table salt, sugar, purchased from one of the supermarkets in Benin City, Nigeria and distilled water was used to prepare the home-produced oral rehydration solution sample. Eight level teaspoons of sugar and one-half level teaspoon of table salt were mixed and stirred properly to ensure a homogeneous solution. Each of the prepared samples were stored in clean containers and properly labeled for analysis.

Viscosity measurement

Viscosity was determined using a U-TUBE viscometer ASTM D-445, D-2515-IP71-BS188 (IRMECO GmbH & Co. KG Schwarzenbek/Germany), Size: 2, n^0: 9285, constant: 0.089559. The analysis of viscosity of distilled water was done with change in temperature from 0 to 60°C and compared with standard values in order to ascertain the accuracy and reliability of the readings obtained from the viscometer.

pH and electrical potential measurement

The pH and electrical potential values were obtained using pH//Electric Potential (mV) meter (SUNTEX SP-701, USA). The instrument was switched on and allowed to be on for about 10 min and the pH probe was rinsed with buffer solutions. Calibration was made of the pH meter using buffer 4.0 and 7.0 solutions. The electrode was then inserted into beakers containing the samples and readings were taken at different temperatures. After taking pH readings, the meter was switched to the mV mode. The probe of the instrument was immersed in the sample solution after the instrument was allowed to stabilize for about 10 min and rinsed with distilled water and reading was recorded.

Electrical conductivity measurement

Electrical conductivity meter, HACH CO-150 was used to determine the conductivity of the samples at different temperatures. The instrument was switched on and allowed to stabilize for 10 min. It was then calibrated by immersing the probe in standard solution of 0.01 M KCl. After rinsing the probe, it was immersed in the beakers containing the samples at different temperatures. The conductivity readings were noted by pressing a button on the conductivity meter.

Calculation of total dissolved solids (TDS)

The values of the TDS for the two samples of ORS were calculated using Equation 1, where σ is the electrical conductivity (Rusydi, 2018).

$$TDS\left(\frac{mg}{L}\right) = 0.65\sigma \quad (\mu S/cm) \qquad (1)$$

RESULTS AND DISCUSSION

The results obtained in this study for viscosity, pH, electrical conductivity, electric potential measurements and calculated values of total dissolved solids are shown in Tables 1 to 3. The viscosity analysis of the HPORS and CPORS alongside distilled with distilled analysis (measured and standard values) is presented in Table 1.

Table 1. Comparison of measured Viscosity values of HPORS, CPORS and Distilled water with variation in temperature.

Temperature (°C)	Viscosity (mPa.s) of HPORS	Viscosity (mPa.s) of CPORS	Viscosity (mPa.s) measured values of distilled water	Viscosity (mPa.s) standard values of distilled water
0	1.48±0.01	1.52±0.01	1.50	1.79
10	1.33±0.03	1.37±0.01	1.30	1.31
20	1.13±0.01	1.16±0.02	1.20	1.00
30	0.90±0.02	1.02±0.01	1.0	0.80
40	0.88±0.01	0.95±0.01	0.90	0.65
50	0.74±0.02	0.82±0.03	0.80	0.55
60	0.52±0.01	0.76±0.01	0.76	0.47

A fluid viscosity is taken as a measure of the resistance it offers to flow as a result of shear stress. In everyday language, viscosity signifies thickness or internal friction. Therefore, water is considered as being thin because of its low viscosity, while honey is regarded as being highly viscous or very thick. The effect which temperature has on viscosity of the samples of ORS in this study was described by the use of Arrhenius equation of activation energy which takes the form:

$$\mu_T = \mu_0 e^{\left(E_a/RT\right)} \qquad (2)$$

where μ_T is viscosity at temperature T, μ_0 is viscosity at zero temperature, E_a is activation energy, R is universal gas constant and T is temperature. It was observed in this study that viscosity decreased as temperature increased in both ORS samples shown in Table 1. This is attributed to the increase in heat energy of the molecules which gave rise to increase in mobility molecules resulting in decrease in the flow resistance (Majunathan and Raju, 2013). The viscosity of the HPORS and CPORS is strongly dependent on inter-molecular forces between molecules and water-solute interactions (salts, sugar and acids). This is brought about by the strength of hydrogen bonds and inter-molecular spacing. In the ORS samples, soluble solids mainly sugar content has a major role to play in magnitude of viscosity (Binder, 2017; Majunathan and Raju, 2013). By reasoning along this line, the results obtained shown in Table 1 revealed that the viscosity values for both ORS samples were higher than the value of sample of distilled water. This is due to the reason that the more the mineral content of a fluid, the higher its viscosity will be. Thus, distilled water has the least mineral content while CPORS has a higher mineral content than its HPORS counterpart. A slight variation in the viscosity of the ORS samples from distilled water could be attributed to the presence of some inactive substances in the solutions. A little variation in viscosity of a fluid sample may not render any problem during pouring into containers (Umeh and Ofoefule, 2013). The overall result of the viscosity test indicated that there was no significant change in the viscosity of the ORS samples and they would therefore, not present any pourability problem during the period of usage. The results of the electrical conductivity and total dissolved solids analysis of the ORS samples are presented in Tables 2 and 3, respectively.

Table 2. Measured Electrical Conductivity (E.C.), pH and Electric Potential (E.P.) Values for HPORS and CPORS with variation in temperature.

Temp. (°C)	E.C. of HPORS (mS/cm)	E.C. of CPORS (mS/cm)	pH of HPORS	pH of CPORS	E.P. of HPORS (mV)	E.P. of CPORS (mV)
0	6.22	2.03	8.01	7.60	88	114
10	5.28	2.16	7.93	7.48	121	118
20	5.90	2.66	7.91	6.80	140	121
30	6.41	4.41	8.13	8.00	142	157
40	11.32	5.65	7.95	7.11	144	158
50	12.68	7.57	7.55	7.20	147	166
60	13.26	9.01	7.42	7.36	151	168

Table 3. Calculated values of TDS for HPORS and CPORS with variation in temperature.

Temp (°C)	0	10	20	30	40	50	60
$TDS\left(\frac{mg}{L}\right)$ HPORS	4043	3432	3835	4167	7358	8242	8619
$TDS\left(\frac{mg}{L}\right)$ CPORS	1320	1404	1729	2867	3673	4921	5857

Electrical conductivity is measured by the ability of a sample of fluid to conduct electric current and it is a function of the fluid temperature and the TDS in it (Agbajor et al., 2021; Rusydi, 2018). The dissolution of salt in a liquid results in the formation of electrical components with opposite electrical charges. Therefore, it was observed that there was a significant difference in the values of HPORS sample as compared to its CPORS counterpart since the electrical conductivity of HPORS increases rapidly with increase in temperature. This may be attributed to the presence of more ions formed as a result of the number of total dissolved solids in the sample by virtue of the temperature increase (Table 3). A general trend of increasing electrical conductivity was observed as temperature increased for the ORS samples because an increase in temperature meant that more molecules of the sample would be dissolved and thus resulting in an increase in the mobility of the ions ready to conduct current of electrical origin more rapidly (Barrett and Keely, 2016; Baron and Ashton, 2007). However, the conductivity values of the home-produced ORS sample are higher than those of the commercially produced ORS samples. This could be indicative of a better quality of the commercially produced ORS than the home-produced ORS samples due to the quality of the salt and water used to prepare the ORS samples. Also, the lower the conductivity of a fluid, the better the quality (Vikesh et al., 2010).

The results obtained from pH and electric potential analysis of the ORS samples are presented in Table 2. The pH of a solution which is defined as a measure of acidity and alkalinity of the solution, has been reported of being linked with the ability to affect the smooth muscle cells located within the cell walls of the blood vessels (Ighoroje, 2014). In order to perform their roles in their chemical as well as their biological environment, these vascular smooth muscles may either contract or dilate so as to influence the pumping action of the heart and thereby affecting the effectiveness of the blood upon which, life depends. Under normal condition, extracellular acidity reduces vascular tones while with mammalian vessels, intracellular acidity increases vascular tone (Ighoroje, 2014). The result of the pH analysis shows that the ORS samples are alkaline. However, the pH of the samples changes slightly with change in temperature. The electric potential increased for the ORS samples with temperature.

Conclusion

From the study, notable significant differences were observed in the measured viscosity and electrical conductivity of the homeproduced ORS and commercial ORS samples in comparison with distilled water at the temperature range of study. Temperature was observed to have a negative effect on the viscosity of the ORS samples while electrical conductivity of the ORS samples was positively affected at the same range of temperature of study. The high electrical conductivity of the home-produced rehydration solution could be indicative of low quality. The pH of the two samples of ORS indicates that the commercial ORS is slightly more acidic than its home-produced counterpart. The values of 7.51 kJ mol^{-1} for the commercially available oral rehydration solution and 7.48 kJ mol^{-1} for the home-produced oral rehydration solution were obtained as the activation energy values for the samples from the viscosity measurements.

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