Electrolyte and glucose contents of ripe and unripe coconut liquid as source of oral rehydration solution

Original Article

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Summary: Electrolyte and glucose contents of 20 ripe and 20 unripe coconuts were analysed along with a commercially prepared oral rehydration solution using flame photometry for sodium, potassium and back titration method for bicarbonate estimation while glucose oxidase method was carried out for glucose estimation. The unripe coconut liquid had mean+ SEM of sodium (mmol/L) 40.08 + 3.21, potassium (mmol/l) 24.06 + 0.89, bicarbonate (mmol/l) 1.48 + 0.20 and glucose (mmol/l) 26.30 + 0.21 while the ripe coconut liquid had sodium (mmol/l) 24.60+ 1.36, Potassium (mmol/l) 15.48 + 0.23, bicarbonate (mmol/l) 0.80 + 0.18 and glucose concentration (mmol/l) of 1.68 + 0.51 respectively. There was significant difference in the electrolyte content of the ripe and unripe coconut liquid (P< 0.05). The commercially prepared ORS had sodium (mmol/l) 90.00 + 0.1, Potassium (mmol/l) 20.00 + 0.1, bicarbonate (mmol/l) 29.00 + 0.1 and glucose concentration (mmol/l) of 111.00 + 0.1 respectively. The electrolyte and glucose contents of the ripe coconut was found not to meet minimum WHO standard of glucose concentration of 111mmol/l, sodium 90mmol/l, Potassium 20mmol/l and bicarbonate concentration of 30mmol/l for ORS. The Potassium concentration of the unripe coconut was higher than minimum WHO standard for ORS. However, the use of coconut liquid for rehydration cannot be recommended on the basis of its glucose and electrolyte composition.

Industrial relevance: Coconut water is often used as an alternative solution for oral rehydration, particularly in regions where mothers’ knowledge of oral rehydration is lacking. There has been no differentiation in the type of coconut water used for the purpose of replacing lost electrolytes; hence the electrolytes lost due to dehydration will not be replaced if the source of rehydration doesn’t contain the proper concentration of electrolytes. The study highlighted the deficiencies in the ripe and unripe coconut water as a rehydration source. Therefore a commercial source of rehydration is still the best source of oral rehydration since the coconut water is deficient in electrolytes to replace lost electrolytes.

Keywords: Electrolyte; glucose; Coconut; Oral Rehydration Solution

INTRODUCTION

The coconut palm is considered the tree of life, since it is one humanity’s principal vegetable resources. Every part of this plant can be utilized: roots, husk, leaves, inflorescence and fruit (Aragão 2000). The fruit of the dwarf coconut palm, particularly the green dwarf coconut palm, are cultivated for their liquid content, whereas the fruit of the giant coconut palm and the hybrids are cultivated for their albumin, which can be used as naturelle or processed into grated dried solids or coconut milk (Ferraz et al., 2003). Flavor varies depending on the stage of maturation of the fruit. Coconut water accounts for 25% of the weight of the fruit, while its basic composition include 95.5% water, 4% carbohydrates, 0.1% fat, 0.02% calcium, 0.01% phosphorous, 0.5% iron, in addition to amino acids, vitamin C, B complex vitamins and mineral salts (Aragão 2000). In some countries coconut water is used...
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as a solution for oral hydration, as part of the daily diet and as a protein supplement when nutritional deficits are intense. During the Second World War, coconut water was even used instead of saline solution during emergency surgeries (Aragão 2000). Some studies suggested that coconut water can be used for intravenous rehydration (Eiseman 1954, Campbell-Falk et al., 2000). Other studies suggest that coconut water can be used for electrolyte replacement in a wide range of situations (Pradera et al., 1942, Kuberski et al., 1979, Chavalittamrong et al., 1982). Studies have compared the chemical composition of coconut water with teas (Collares and Souza 1985) still soft drinks (Chavalittamrong et al., 1982), carbonated soft drinks (Chavalittamrong et al., 1982, Collares and Souza 1985), isotonic drinks (Saat et al., 2002) and oral rehydration solution (ORS)( Adams and Bratt 1992). Coconut water is often used as an alternative solution for oral rehydration, particularly in regions where mothers' knowledge of oral rehydration is lacking, thus avoiding incorrect preparation of sugar-salt solutions (Toporovski et al., 1995, Sena et al., 2001). Over the years studies have been conducted in search of improved oral rehydration solution (ORS). Recently, the focus has been on the optimal glucose concentration and osmolarity of these preparations (Tarja, 2000).The minimum electrolyte content as recommended by WHO include sodium (90mmol/l), Potassium (20mmol/l), chloride (80mmol/l) and bicarbonate (30mmol/l) (World Health Organization 2001).The biochemical profile of coconut water varied as the coconuts matured (Vigliari et al., 2006). Coconut water from dwarf coconut palms has been compared with ORS, and it was observed that neither the concentrations of glucose, sodium, potassium and chloride, nor the osmolarity of the coconut water from inland palms met the WHO recommendations for ORS (Viglieri et al., 2006). In a comparative study, the carbohydrate and electrolyte levels of kenkey water (a maize gruel) which are traditionally used for the treatment of diarrhoea in Ghana, were found to be comparable to UNICEF/WHO ORS and is suitable for use in rehydration while Coconut milk which has the advantages of being fresh, sterile and readily available in most Ghananian communities was not suitable on the basis of its glucose and electrolyte composition (Yartey et al., 1993). Coconut water is being used as source of oral rehydration without recourse to the nature of its ripeness. Studies has been carried out on electrolyte content of coconut without recourse to the nature of it’s ripeness. Therefore, this study is aimed at investigating the electrolyte and glucose contents of both ripe and unripe coconut to assess their usefulness in treatment of dehydration.

MATERIALS AND METHODS

Twenty ripe and unripe coconuts each were purchased from a local market in Port Harcourt. The coconuts were cut open. The contents poured into labeled sterile containers for electrolyte estimation while some were added to fluoride oxalate bottles for glucose estimation. Also Oralab, a commercially prepared ORS was purchased from a Pharmaceutical store in Port Harcourt. This was dissolved and mixed as stipulated by the manufacturer i.e. a sachet into 1 L of drinking water.

Flame emission Spectrophotometry: Sodium and potassium content of each combination including the Oralab solution was determined by Flame emission Spectrophotometry (Cheesebrough 1987 and Baker et al., 1998) using Gallenkamp flame photometer. Using compressed air, the coconut water or Oralab was sprayed as a fine mist of droplets (Nebulised) into a non luminous gas flame which becomes coloured by the characteristic emission of the sodium or potassium metallic ions in the sample. Light of a wavelength corresponding to the metal being measured was selected by a light filter or prism system and allowed to fall on a photosensitive detector system. The amount of light emitted depends on the concentration of metallic ions present. Accuracy was controlled by analyzing a sodium potassium standard solution (140/3.0mmol/l) respectively after every two (2) analysis to correct for instrument drift while a Randox normal quality control serum was assayed to determine the precision. Bicarbonate content of each combination was determined by Back titration method using 0.01N HCL and 0.01NaOH while glucose estimation was done using glucose oxidase method (Barham, and Trinder 1972).

Statistical analysis: The data generated in this study were subjected to statistical analysis using SPSS version 16 and result presented as Mean + SEM. Correlations among the biochemical determinations were calculated. A value of P<0.05 was accepted as significant and a value of P>0.05 was considered not significant.

RESULTS

The result of the study showed that unripe coconut had electrolyte concentrations of 40.80 + 3.21, 24.06 + 0.89, 1.48 + 0.20, 26.30 + 1.10 and 155.50 + 4.80 for sodium (mmol/l), Potassium (mmol/l), Bicarbonate (mmol/l), glucose (mmol/l) and volume (ml) respectively. Also ripe coconut had electrolyte values of 24.60 + 1.36, 15.48 + 0.23, 0.80 + 0.18, 1.68 + 0.51 and 52.60 + 3.05 for sodium (mmol/l), Potassium (mmol/l), Bicarbonate (mmol/l), glucose (mmol/l) and volume (ml) respectively. There was significant difference in the electrolytes, glucose and volume (P<0.05) (Table 1).

The result of the study showed that unripe coconut had electrolyte range values of 20-70, 19.50-30.60, 0.00-3.00, 18-35 and 110.00 -188.00 for sodium (mmol/l), Potassium (mmol/l), Bicarbonate (mmol/l),
glucose (mmol/l), and volume (ml) respectively. Also ripe coconut had electrolyte values of 13-35, 13.00 – 17.00, 0.00- 2.50, 0.50 - 10.90 and 30.00- 98.00 for sodium (mmol/l), Potassium (mmol/l), Bicarbonate (mmol/l), glucose (mmol/l) and volume (ml) respectively (Table 1).

**Table 1.** Electrolyte contents and ranges of ripe and unripe coconut liquid

<table>
<thead>
<tr>
<th>Electrolyte (MMOL/L)</th>
<th>Unripe Coconut</th>
<th>Ripe Coconut</th>
<th>P Value</th>
<th>Unripe Coconut</th>
<th>Ripe Coconut</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>40.80 ± 3.21</td>
<td>24.60± 1.36</td>
<td>P&lt;0.05</td>
<td>20-70</td>
<td>13-35</td>
</tr>
<tr>
<td>Potassium</td>
<td>24.06 + 0.89</td>
<td>15.48+ 0.23</td>
<td>P&lt;0.05</td>
<td>19.5-30.6</td>
<td>13.0-17.0</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>1.48 ± 0.20</td>
<td>0.80± 0.18</td>
<td>P&lt;0.05</td>
<td>0.00-3.00</td>
<td>0.00-2.50</td>
</tr>
<tr>
<td>Glucose</td>
<td>26.30 + 1.10</td>
<td>1.68 + 0.51</td>
<td>P&lt;0.05</td>
<td>11-15</td>
<td>0.5-10.9</td>
</tr>
<tr>
<td>Volume (ml)</td>
<td>155.50 + 4.80</td>
<td>52.60 + 3.05</td>
<td>P&lt;0.05</td>
<td>110-118</td>
<td>30-98</td>
</tr>
</tbody>
</table>

The commercially prepared ORS had sodium (mmol/l) 90.00+ 0.1, Potassium (mmol/l) 20.00 ± 0.1, bicarbonate (mmol/l) 29.00 + 0.1 and glucose concentration (mmol/l) of 111.00 + 0.1 respectively (Table 2).

**Table 2.** Electrolyte contents of ripe, unripe coconut liquid and commercial ors

<table>
<thead>
<tr>
<th>Electrolyte (MMOL/L)</th>
<th>Commercial ORS</th>
<th>Ripe Coconut</th>
<th>P Value</th>
<th>Commercial ORS</th>
<th>Unripe Coconut</th>
<th>Ripe Coconut</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>90.00+ 0.1</td>
<td>24.60+ 1.36</td>
<td>P&lt;0.05</td>
<td>90.00+ 0.1</td>
<td>40.80 + 3.21</td>
<td>P&lt;0.05</td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>20.00 + 0.1</td>
<td>15.48+ 0.23</td>
<td>P&lt;0.05</td>
<td>20.00 + 0.1</td>
<td>24.60 + 0.89</td>
<td>P&lt;0.05</td>
<td></td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>29.00 + 0.1</td>
<td>0.80± 0.18</td>
<td>P&lt;0.05</td>
<td>29.00 + 0.1</td>
<td>1.48 + 0.20</td>
<td>P&lt;0.05</td>
<td></td>
</tr>
<tr>
<td>Glucose</td>
<td>111.00 + 0.1</td>
<td>1.68 ± 0.51</td>
<td>P&lt;0.05</td>
<td>111.00 + 0.1</td>
<td>26.30 + 1.10</td>
<td>P&lt;0.05</td>
<td></td>
</tr>
</tbody>
</table>

**DISCUSSION**

Coconut water is often used as an alternative solution for oral rehydration, particularly in regions where mothers' knowledge of oral rehydration is lacking, thus avoiding incorrect preparation of sugar-salt solutions (Toporovskiet al., 1995, Sena et al., 2001). The result of this study showed that unripe coconut is richer in electrolyte and glucose content than ripe coconut but did not meet WHO requirement for ORS concentrations of sodium, bicarbonate and glucose. WHO standard specifies 90 mmol/l, 20mmol/l, 30mmol/l and 111mmol/l for sodium, potassium, bicarbonate and glucose respectively.

Bayard (1981) reported that liquid content of coconut fruit diminishes gradually as it is being absorbed by the fruits as it ripens confirming the result of our study which showed high liquid volume in unripe coconut than ripe coconut. The biochemical profile of coconut water was also shown to vary as the coconuts matured (VigliarI et al., 2006). It has been observed that potassium reduced as the coconut ripens (VigliarI et al., 2006) confirming the result of our study which showed high Potassium concentration in Unripe coconut than the ripe coconut. In some countries coconut water is used as a solution for oral hydration, as part of the daily diet and as a protein supplement when nutritional deficits are intense.

The result of this study showed that electrolytes (sodium, Potassium and bicarbonate) and glucose concentration of ripe did not meet WHO minimum requirement for ORS while in the unripe coconut sodium, bicarbonate and glucose concentrations did not meet WHO minimum requirement for ORS. This is similar to the study in Ghana (Yartey et al., 1993) which showed that Coconut liquid did not meet WHO electrolyte standard. Also concentrations of glucose, sodium, potassium, chloride, and the osmolarity of the coconut water from inland palms was compared with ORS but found not to meet the WHO recommendations for ORS (VigliarI et al., 2006). The elevated concentration of potassium means that coconut water could possibly be used to replace that electrolyte.

Electrolyte imbalance and fluid loss also causes metabolic acidosis. These effects are more critical in the case of infants, as their renal function is not fully developed and they have a large surface area in ratio to body weight and a higher metabolic rate. Acidosis is corrected by the addition of bicarbonate (or another base such as citrate) to the ORS formula (Roger 2010). The low bicarbonate concentration in both the unripe and ripe coconut liquid made it unsuitable to correct acidosis.
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in dehydration. The glucose molecules are absorbed through the intestinal wall - unaffected by the diarrhoeal disease state - and in conjunction sodium is carried through by a co-transport coupling mechanism. This occurs in a 1:1 ratio, one molecule of glucose co-transporting one sodium ion (Na+). Potassium is not involved in any way in the sodium/glucose co-transport mechanism and is absorbed passively (Roger 2010).

The mean sodium observed in both ripe and unripe coconut is similar to previous studies (Eiseman 1954, Campbell-Falck et al., 2000 Pradera et al., 1942, Kuberskiet al., 1979, Collares and Souza 1985, Saatet al., 2002, Adams and Bratt 1992, VigliarI et al., 2006). Comparing the composition of the ORS recommended by the World Health Organization (WHO)(1990) with the results of studies that have analyzed coconut water, it will be observed that the sodium concentration in the coconut water is far below that in the ORS. Also in the results of the current study, potassium concentration was above that in rehydration oral salts (20mmol/L) which is similar to VigliarI et al (2006). In the current study the concentration of glucose was below what is recommended for ORS by the WHO at the ripe and unripe stages of maturation of the coconuts.

When we compared both ripe and unripe coconut water with ORS, we observed that neither the concentrations of glucose, sodium, potassium and bicarbonate of the coconut water met the WHO recommendations for ORS. Consequently commercially prepared ORS is still preferable for rehydration.

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