

# Influence of Concentration and Type of Sugar Additives on the Osmolality and Acceptance of Coconut Water

## Influência da Concentração e Tipos de Açúcares na Aceitação e Osmolaridade da Água de Coco

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### Abstract

*Diet formulations and health drinks with low osmolality has been used to enteral nutrition and electrolytes reposition and coconut water have a great potential to it. To other hand, the use of sugars, besides increase osmolality, is advantageous to industries to permit obtain a product with sweet taste standardized. In order to evaluate the effect of types of sugars on coconut water osmolality an experiment was laid out in a completely randomized 3x4 factorial design with three types of sugars (glucose, fructose and sucrose) and four concentrations of sugar (0 g.kg<sup>-1</sup>, 5 g.kg<sup>-1</sup>, 10 g.kg<sup>-1</sup> and 15 g.kg<sup>-1</sup>). It was verified that tested concentration and types of sugars affects significantly (p < 0.05) the coconut water osmolality. However, at the tested levels the product is still less hypertonic than a great number of existent beverages, remaining as an alternative as refreshing and re-hydration beverage. Fructose, among tested sugars, is the one which promotes less impact on osmolality and its addition in increasing levels improved the acceptability, being a good alternative to standardize the sweet taste on industrial process.*

**Keywords:** Fluid Therapy. Beverages. Osmolar Concentration. Food Habits.

### Resumo

Formulações de dieta e bebidas saudáveis com baixa osmolalidade têm sido utilizadas para nutrição enteral e reposição de eletrólitos. Dentre diferentes bebidas utilizadas com este fim, a água de coco tem sido grandemente utilizada, em função, principalmente da osmolaridade similar aos dos fluidos corpóreos. Com a intensificação na industrialização da água de coco tem sido comum a adição de açúcares com o intuito de obter uma bebida com gosto doce padronizado; no entanto, esta prática tem gerado aumento da pressão osmótica. A fim de avaliar o efeito dos tipos de açúcares na osmolalidade da água de coco um delineamento experimental inteiramente casualizado em um esquema fatorial 3x4, com três tipos de açúcares (glicose, frutose e sacarose) e quatro concentrações (0, 5, 10 e 15 g.kg<sup>-1</sup>) foi conduzido. Verificou-se que as concentrações testadas e tipos de açúcares afetaram de forma significativa (p < 0,05) a pressão osmótica da água de coco. No entanto, nos níveis testados o produto ainda é inferior hipertonicamente a um grande número de bebidas existentes, mantendo-se como uma bebida refrescante e de re-hidratação. A frutose, dentre os açúcares testados, é o que promoveu menor impacto sobre a osmolalidade e sua utilização em níveis crescentes aumentou a aceitação sensorial da água de coco, apresentando-se como uma boa alternativa para padronizar o gosto doce no processo industrial.

**Palavras-chave:** Hidratação. Bebidas. Concentração Osmolar. Hábitos Alimentares.

### 1 Introduction

Coconut trees are economic plants in many tropical countries, and often called “trees of life” due to productivity and great variety of products there are consumed and utilized by humans<sup>1,2</sup>. Coconut water (CW), the liquid endosperm of coconut (*Cocos nucifera* L.), represents around of 250.0 g.kg<sup>-1</sup> of the fruit weight, and their basic composition is 955 g.kg<sup>-1</sup> water, 40.0 g.kg<sup>-1</sup> carbohydrates, 1.0 g.kg<sup>-1</sup> fats, 0.2 g.kg<sup>-1</sup> calcium, 0.1 g.kg<sup>-1</sup> phosphorus, 5.0 g.kg<sup>-1</sup> iron, and amino acids, vitamin C, vitamin B complex and minerals<sup>3</sup>.

Coconut water, in its unprocessed form, is a refreshing and nutritious beverage<sup>4,5</sup>. Rich in carbohydrates, vitamins and minerals, it is consumed around the world for their nutritional characteristics. Also, it is common sense that coconut water can be used as an important alternative to oral and enteral re-

hydration due to its osmolality<sup>6</sup>.

Osmolality represents a measure of number of particles in a kilogram of water (osmoles per kilogram)<sup>7</sup>. This is an often-ignored physicochemical factor with great importance in determining the efficacy of oral rehydration solutions (ORS) in water and electrolyte absorption rates<sup>8</sup>.

Besides the importance in ORS, an adequate osmolar load is necessary for alimentation infused directly via nasogastric or nasoenteric of individuals submitted to enteral nutrition or with intestinal complications (diarrhea and vomiting), thus ensuring the success of the dietotherapeutic<sup>9</sup> plan. The adequate osmolar load also is important to the hydroelectrolytic reposition, once a fluid more similar to physiological fluids promote a faster absorption of salts and water<sup>1</sup>.

Low osmolality of coconut water is a feature that makes

it an interesting alternative for using in formulations of enteral diets produced in craft, since osmolality is a key physiological uptake in the diet<sup>11</sup>. Even the coconut water is less hypertonic than a great number of existent beverages, remaining as an alternative as refreshing and re-hydration beverage. Saat et al.<sup>16</sup> studying rehydration after exercise verified that coconut water (osmolality of 405 mOsm kg<sup>-1</sup>) did not differ of water or carbohydrate-electrolyte beverage. However, coconut water was significantly sweeter, caused less nausea, fullness and no stomach upset and was also easier to consume in large amounts. Evans et al.<sup>17</sup> verified that more hypertonic formulations with the presence of carbohydrates (glucose) had a better response in postexercise rehydration than compared to dilute solutions with same electrolytes composition. Moukarzel and Sabri<sup>18</sup> in a study about the effect of fruit juices in gastric physiology related the slower gastric emptying rate for glucose solutions when compared to fructose solutions and that the amount of carbohydrate is more important to it than osmolality.

Glucose and fructose in coconut water are the substances that provide the sweet taste of this product<sup>12</sup>. As the consumption and production of bottled coconut water increases, it has been noticed a tendency from industries to standardize the sweet taste. However, it should be noted that the sugar can cause changes on osmolality of this product.

Therefore, the objective of this study was to verify the effect of different types and concentrations of sugars on the osmolality of coconut water and verify the acceptance of the product added of the sugar which provide less impact on osmolality.

## 2. Material and Methods

### 2.1 Material

Green coconuts were acquired from different producers in different weeks in the southern region of Bahia, Brazil. A total of 110 green coconuts of Bahia variety between 6 and 8 months maturation were divided into three lots of 20 units each (for osmolality experiments) and one lot of 50 units (for sensory analysis). Water was manually removed by a hole opened at the top. Then, water passed through a domestic paper filter, being obtained a volume near to 400 mL by unit. Each lot was then standardized to a soluble solids content of 5.0 °Brix using distilled water and a portable refractometer. To prepare the tested treatments, the sugars fructose, sucrose and glucose, all of analytical grade, were used in adequate concentrations. Standardized coconut water was poured in plastic bottles of a half liter and then stored in refrigeration (6.0 °C) for maximum five days.

### 2.2 Experimental design

In order to study the effect of type of sugar on the coconut water osmolality, an experiment in a factorial 3x4, three types of sugars (glucose, sucrose and fructose) in four levels of

addition (0 g.kg<sup>-1</sup>, 5.0 g.kg<sup>-1</sup>, 10.0 g.kg<sup>-1</sup> and 15.0 g.kg<sup>-1</sup>) was conducted, installed in a completely randomized design with three repetitions.

The results were submitted to analysis of variance (ANOVA) and linear regression analysis, both with 5% of significance ( $p < 0.05$ ), using the software SAEG v. 8.1<sup>14</sup>. The choice of the best model was made based on determination coefficient ( $R^2$ ), parameters significance and residual analysis.

### 2.3 Determination of osmolality

To study the addition of different sugars on osmolality of coconut water, 3 lots of 20 units of green coconuts were used, totaling three repetitions. In each lot was obtained around of 8 L of coconut water. The water was extracted and standardized as described previously. Once standardized each lot was divided into twelve equal parts, which were added appropriate quantities of fructose, glucose and sucrose, for all experimental treatments. The osmolality was determined by cryoscopic method, based on proportionality between the elevation in the concentration of solute in solution and reduction of the freezing point of it (cryoscopic descent). The freezing point of the samples was determined using an electronic cryoscopic (model LK-7000, Laktron, SP) in three replicates. The osmolality was then calculated according to Henriques and Rosado<sup>9</sup>.

### 2.4 Sensory analysis

To sensory analysis were used 20 L of coconut water extracted from 50 green coconuts. The water was extracted and standardized as described previously and divided into four lots in which were added fructose in adequate amounts to concentrations of 0 g.kg<sup>-1</sup>, 5.0 g.kg<sup>-1</sup>, 10.0 g.kg<sup>-1</sup>, and 15.0 g.kg<sup>-1</sup>. Fructose was chosen for presenting a smaller effect on coconut water osmolality.

It was applied an acceptance test with hedonic scale of nine points (with extremes in “like extremely” and “dislike extremely”) (Minim, 2006). The samples were presented in plastic cups of 50 mL, in monadicham, coded and randomized, in individual booths under white light, for a total of 70 untrained tasters, of both sexes, aged 20 to 45 years.

## 3 Results

### 3.1 Effect of concentration and type of sugar on coconut water osmolality

To samples tested in this work, the highest values of osmolality observed were 449.77 mOsm.kg<sup>-1</sup>, 500.95 mOsm.kg<sup>-1</sup> and 498.77 mOsm.kg<sup>-1</sup> for addition of fructose, glucose and sucrose, respectively, at a concentration of 15 g.kg<sup>-1</sup> to all of them.

The experimental results were submitted to ANOVA, being observed that the two factors studied and their interaction were significant ( $p < 0.05$ ). In all cases the fitted parameters were significant ( $p < 0.05$ ), the determination coefficient was

greater than 0.95 and residual analysis was satisfactory. Table 1 shows the regression analysis of the quadratic model.

**Table 1:** Regression analysis for the effect of type of sugar in the osmolality of coconut water

Source	DF	Mean Square	F Value
<b>Concentration/Sucrose</b>	3	7095.15	744.24
Linear coefficient	1	19958.87	2093.57*
Quadratic coefficient	1	1128.27	1105.96*
Lack of fit	1	198.33	20.80*
<b>Concentration/Fructose</b>	3	2186.68	229.37
Linear coefficient	1	6286.71	659.44*
Quadratic coefficient	1	244,78	342.56*
Lack of fit	1	28.55	2.99 <sup>n.s</sup>
<b>Concentration/Glucose</b>	3	7289.13	764.59
Linear coefficient	1	21163.97	2219.98*
Quadratic coefficient	1	675.59	1145.42*
Lack of fit	1	27.84	2.92 <sup>n.s</sup>
TRAT	11	5152.323	
RES	24	9.53341	
TOTAL	35		

\*Significant at 5% probability. <sup>n.s</sup> not significant at 5% probability.

The three equations obtained for fructose, glucose and sucrose, respectively, are presented in Equations 1, 2 and 3, respectively.

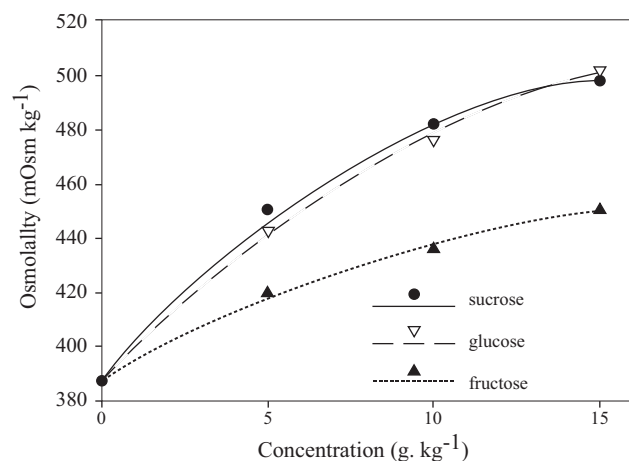
$$\text{OSM}=388.3752+6.8043\text{CONC}-0.1807\text{CONC}^2 \quad R^2=0.99 \quad (1)$$

$$\text{OSM}=388.3665+12.0144\text{CONC}-0.3001\text{CONC}^2 \quad R^2=0.99 \quad (2)$$

$$\text{OSM}=389.5036+13.1133\text{CONC}-0.3879\text{CONC}^2 \quad R^2=0.99 \quad (3)$$

where OSM is the osmolality of coconut water in mOsm.kg<sup>-1</sup> and CONC the concentration of coconut water in g.kg<sup>-1</sup>.

On figure 1 it was observed that the glucose and sucrose had greater impact on osmolality than fructose.



**Figure 1:** Effect of concentration and type of sugar on the osmolality of coconut water

### 3.2 Sensory analysis

After verification of the effect of different sugars on the osmolality of coconut water, it was decided to use fructose for sensory studies, since this was the sugar that had lower elevation in the variable studied. The results obtained in the acceptance test, that mean scores for acceptance of all treatments were located between the hedonic terms “like slightly” (score 6) and “liked a lot” (score 8). The mean scores for acceptance of coconut water added of fructose at levels of 0 g.kg<sup>-1</sup>, 5.0 g.kg<sup>-1</sup>, 10.0 g.kg<sup>-1</sup> and 15.0 g.kg<sup>-1</sup> were 6.81, 7.06, 7.37 and 7.40, respectively.

It was observed that the acceptance increased as the content of fructose. Then, a simple linear model was fitted, with significant parameters ( $p < 0.05$ ), good determination coefficient and residual analysis (Table 2). The fitted model is presented in Equation 4:

$$\text{ESC} = 6.8500 + 0.0414\text{CONC} \quad R^2 = 0.92 \quad (4)$$

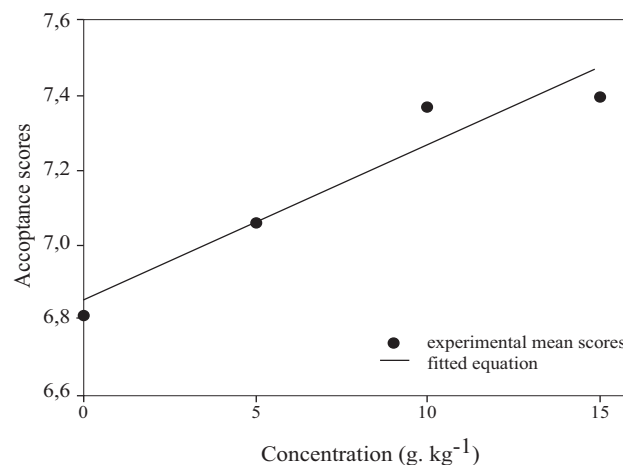
where ESC represents the mean scores assigned to samples, ranging from 1 to 9, and CONC is the concentration of fructose added to coconut water (g.kg<sup>-1</sup>).

**Table 2:** Regression analysis of the effect of fructose concentration in coconut water acceptance

Source	DF	Mean Square	F Value
Linear coefficient	1	15.02	6.76*
Lack of fit	2	0.63	0.28 <sup>n.s</sup>
TRAT	3	5.42	2.44
RES	276	2.22	
TOTAL	279		

\*Significant at 5% probability. <sup>n.s</sup> not significant at 5% probability

The positive value of the slope in Equation 4, indicates that the sensory acceptance of coconut water increases when fructose concentration increase, in the studied range, which can be seen in figure 2.



**Figure 2:** Effect of addition of fructose in the acceptance of coconut water

#### 4 Discussion

It was showed that coconut water, even added to sugars in tested concentrations, can be considered a drink with slightly hypertonic effect if compared to apple juice, orange juice and grape juice, with osmolality of 718 mOsm kg<sup>-1</sup>, 622 mOsmkg<sup>-1</sup> and 1174 mOsm kg<sup>-1</sup>, respectively<sup>15</sup>.

The different increase at the osmolality with glucose and sucrose adding compared with fructose was not expected once that for the same mass, compounds with same molar mass, as glucose and fructose, had the same number of molecules and theoretically should affect equally the osmolality of the samples. Molecules of different molar mass, as sucrose and glucose, should provide different numbers of molecules, affecting differently the osmolality<sup>19</sup>. It was expected that glucose and fructose present similar effect on osmolality and which both exert greater impact than sucrose, since these sugars had half of molar mass of sucrose.

One possible explanation for this behavior is that coconut water, like all foods, is a complex biological system composed of mixtures of macro and micro-nutrients that interact in ways not fully known. The added molecules of fructose and glucose, that are reducing sugars, may have interacted with compounds in coconut water, especially with some electrolytes, making them less osmotically actives. Although the glucose and fructose have the same molar mass, the fructose is more reactive, allowing it to interact with many components, causing less elevation in activity of the osmotic system.

The increase in sensory acceptance of coconut water was expected since sugars and minerals are the ones that give to coconut water a pleasant taste<sup>20</sup>.

#### 5 Conclusions

From experimental results, it was verified that tested concentrations and types of sugar affect significantly ( $p < 0.05$ ) the coconut water osmolality. However, at the tested levels the product is still less hypertonic than a great number of existent beverages, remaining as an alternative as refreshing and rehydration beverage. Fructose, among tested sugars, is the one which promotes less impact on osmolality and its addition in crescent levels increases the sensory acceptance of coconut water, being a good alternative to standardize the sweet taste on industrial process.

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