

THE REHYDRATION POTENTIAL OF ZEA MAYS JUICE COMPARED TO CARBOHYDRATE-ELECTROLYTE BEVERAGE

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Abstract

The purpose of rehydration is to replace fluid and electrolyte losses. Carbohydrates and sodium are the main nutrient sources for rehydration. The presence of protein aids the rehydration process and thereby promoting muscle synthesis. *Zea mays* had been identified as one of the potential food sources that could be an alternative recovery beverage. The aim of this study was to assess the potential of *Zea mays* (ZM) juice as an alternative rehydration beverage. A total of 15 male participants were involved in this study. They were required to cycle to 70-80% of their age predicted maximum heart rate until they were dehydrated (1.8-2% body weight loss). Then they were given either ZM juice or CE drink in an amount representing 150% of their initial body weight loss. After 4-hours of rest with no other food allowed, their USG and percentage of fluid retention were calculated. Results showed that ZM juice had better retention and demonstrated well hydrated USG readings compared to CE drink. Therefore, ZM juice has the potential to be an alternative rehydration beverage.

Keywords: hydration, exercise, carbohydrate-protein beverage, rehydration beverage, *Zea mays*

INTRODUCTION

Exercise inevitably leads to water losses and the fluid consumption by athletes during a sports event is usually less than the amount of fluid lost. This condition will lead to a negative fluid balance that results in the athlete being in a hypohydrated condition and this is typically what usually happens at the end of the exercise session. It is necessary for fluid replacement after the exercise session to be planned so as to replace the fluid and electrolyte losses especially when the exercise task is prolonged and/or is undertaken in a hot environment (Cheuvront & Kenefick, 2014; Sawka, Cheuvront, 2005; Sawka et al., 2007; Sawka, Cheuvront, & Kenefick, 2015). Even though

some studies have shown the occurrence of less performance effects due to dehydration (Cheung et al., 2015; Fleming & James, 2014), the majority of the literature suggests that body deficits which approximate 2% of body mass may impair an athlete's performance. Therefore commencing exercise in well hydrated state is likely to offer the best strategy to optimize exercise performance in most exercise settings.

The ability of the body to retain fluid helps for a better rehydration process. Maughan et al. 2016 described the Beverage Hydration Index (BHI) where the hydration potential of beverages are identified. It is important for those who have limited access to fluid ingestion and where frequent breaks to urinate are not desirable. For beverages with a high BHI, the fluids will be retained longer and could help bodily systems in rehydration. Studies have found that factors that enhance rehydration ability include, volume of fluid ingestion that is more than fluid loss (Shirreffs, Taylor, Leiper, & Maughan, 1996), sodium content (Maughan & Leiper, 1995; Merson, Maughan, & Shirreffs, 2008; Shirreffs & Maughan, 1998) and the presence of carbohydrates (Clayton, Evans, & James, 2014; Evans, James, Shirreffs, & Maughan, 2017). Protein-containing beverages have also been proven to enhance the rehydration process by increasing water uptake (Seifert, Harmon, & DeClercq, 2006; Wapnir, Wingertzahn, & Teichberg, 1997).

Carbohydrate-electrolyte (CM) drinks are well known to have certain hydration benefits (Lee, Nio, Ang, Law, & Lim, 2011; Osterberg, Pallardy, Johnson, & Horswill, 2010). Besides that, several studies have determined that milk and milk based beverages could enhance the rehydration process after exercise (Desbrow, Jansen, Barrett, Leveritt, & Irwin, 2014; James, Clayton, & Evans, 2011; Seery & Jakeman, 2016; Shirreffs, Aragon-Vargas, Keil, Love, & Phillips, 2007; Watson, Love, Maughan, & Shirreffs, 2008). Unfortunately, milk and milk based beverages are not a good for those who are lactose intolerant or with hypolactasia (Asmawi, Seppo, Vapaatalo, & Korpela, 2006) due to the consequences of these conditions on afflicted athletes. Therefore the purpose of this study was to examine if *Zea mays* (ZM) could be an alternative product with the potential to meet rehydration purposes as it contains the nutrients needed for recovery purposes. ZM juice contains the nutrients that are required for rehydration purposes. We therefore hypothesize that ZM juice may be able to serve as a rehydration beverage with better retention characteristics compared to commercially CM drinks.

METHOD

Participants

A total of 15 male participants were involved in this study. The design of this study was a repeated cross over design where each participant repeated the same protocol within 7 days for each of the beverages. The participants should be involved in physical activities for at least 3 days per week with no medical illnesses or complications based on the self-answered questionnaire given to them. They were asked to refrain from performing strenuous exercise 24 hours prior to the testing day. They must also complete a diet record beginning 24 hours before testing and comply with the same food intake during the second test. After they were briefed on the protocol of the test, they agreed

to participate and signed the consent form. There was also a simulation day conducted one week before the real testing day for familiarization purposes.

Procedures

On the day of test, the participants arrived in the morning according to the schedule provided to them. They were required to fast 12 hours prior to the test and only plain water *ad libitum* was allowed. Before the test started, the participants provided a urine sample and their nude body weight was measured. A portable refractometer analyzer (PAL-10S Atago, Japan) was used to measure urine specific gravity (USG) to ensure that the participants started the exercise in a well hydrated condition. If the USG value was more than 1.020, they would be given 300 ml plain water to consume and then waited until they could pass another urine specimen. They were allowed to start the protocol when they were in a well hydrated status (USG below 1.020). All the participants wore a heart rate monitor (CHR100 Casio, Japan) while cycling.

The participants then cycled (Sole B94, USA) at 70-80% of their age predicted maximum heart rate. They were told to keep cycling within their predicted maximum heart rate and stopped momentarily for body weight measurements. The participants were informed of how much body weight they should lose to achieve approximately 1.8% loss of their body weight. After they reached the desirable weight, they were allowed to take a bath and change their clothes. They then returned to the lab to measure their final body weight before consuming the test beverage. They were required to consume 150% of their body weight loss within an hour for each session. The amount of the beverages were given equally for every 15 minutes. Then they would rest in the lab with minimal movement. They were allowed to do their work using a laptop or otherwise watched movies provided in the lab.

Each of them was also provided with urine sample collection bottles and asked to collect and the amount of urine they passed every hour were calculated. At the end of 4 hours, urine samples were taken for USG assessment. Then the participants were dismissed and allowed to consume their normal meals.

Data analysis

All the data analysis was performed using SPSS Statistics for Windows, version 23.0 (IBM Corp. 2015, Armonk, N.Y., USA). Participant characteristics were describe by using descriptive analysis while statistical analysis concerning the hydration potential between two beverages was analyzed using paired t-test significant value was set at $p < 0.05$. Fluid retention was calculated using the following equation:

$$\text{Fluid retention} = \frac{(\text{volume of beverage consumed} - \text{total urine output after 4 h})}{(\text{volume of beverage consumed})} \times 100$$

RESULTS AND DISCUSSION

The nutrient value of ZM juice was analyzed for calorie, macronutrients and sodium content. ZM juice had been prepared isocaloric to CE drinks. The content of the ZM juice as in Table 1.

Table 1: Nutrient content of Zea mays juice (ZM) comparable to carbohydrate-electrolyte drink (CE)

<i>Nutrient (100ml)</i>	<i>ZM</i>	<i>CE</i>
<i>Calories (kcal)</i>	21.6	21.6
<i>Carbohydrate (g)</i>	4.2	5.6
<i>Protein (g)</i>	0.7	NA
<i>Fat (g)</i>	0.2	NA
<i>Sodium (mg)</i>	53.6	40.4

Both of the test beverages contain the same amount of calorie. ZM juice contain protein (0.7g/100 ml) and fat (0.2g/100 ml). Therefore the total of carbohydrate contain was lower compared to EC drinks, while the amount of sodium content was higher in ZM juice compared to CE drinks.

The age of the participants was 21.2 ± 2.2 years old, body weight was 66.1 ± 10.2 kg, height 170.9 ± 5.5 cm with their average BMI's being 22.6 ± 2.9 kg/m². All of the participants were physically active and were university athletes who are actively participating in competitions. Table 2 shows the results of the rehydration assessments variable.

Table 2: Rehydration characteristic between Zea mays juice (ZM) and carbohydrate-electrolyte drink (CE)

<i>Category</i>	<i>ZM</i>	<i>CE</i>	<i>P value</i>
<i>% of body weight loss</i>	1.94±0.14	2.02±0.18	0.164
<i>Total fluid consume (ml)</i>	1960 ± 302	2020 ± 334	0.233
<i>Total urine output (ml)</i>	1022 ± 415	1418 ± 425	0.043*
<i>% of fluid retention</i>	48 ± 18.7	28.5 ± 21.7	0.042*
<i>USG before exercise</i>	1.018±0.001	1.017±0.003	0.316
<i>USG after exercise</i>	1.009±0.003	1.008±0.006	0.542

*Data have significant difference when $p < 0.05$

During both sessions of the assessment, there were no significant differences in body weight loss ($p=0.164$). This shows that the participants achieved the objective of losing the approximated weight to establish a hypo hydrated state. Then they consumed 2020 ± 334 ml of CE drink versus 1960 ± 302 ml of ZM juice according to their body weight losses. There was also no significant difference ($p=0.233$) between the amount of fluid they consumed after exercise. The total fluid consumption was calculated as being 150% of their body weight loss (Shirreffs et al., 1996). The participants then completed fluid consumption within an hour after exercise and the sessions of fluid ingestion were divided into 4 sessions. At the end of ZM juice consumption, there were participants who responded that they had a feeling of satiety after finishing the juice when

compared to consuming CE drink. They also reported still feeling full after consuming the *ZM* juice at the end of rehydration test session (4 hours and without food). This is likely due to the protein and fat content in the juice making it denser when compared to CE drinks (Clayton et al., 2014; Maughan et al., 2016).

Meanwhile, there were significant differences in the total urine output of participants when they consumed CE drink and *ZM* juice ($p=0.043$) and in the percentage of fluid retention between the two beverages ($p=0.042$). *ZM* juice consumption produced less urine ($1022\pm 415\text{ml}$) and retain more ($48\pm 18.7\%$) when compared to CE drink (urine output= $1418\pm 425\text{ ml}$; percentage of fluid retention= $28.5\pm 21.7\%$). The ability to retain fluid after consuming *ZM* juice shows that it lasts longer in the body and thus could most likely enhance the rehydration process (Maughan et al., 2016). This study results show that *ZM* juice has the ability to replace fluid loss and retained more body fluid, hence results in less urine production (Table 2) when compared to CE drink. The carbohydrate, protein and sodium content in *ZM* juice one likely to have promoted the rehydration potential of the beverage as reported before (Evans et al., 2017; Shirreffs & Sawka, 2011; Shireffs & Maughan, 2000). James and colleagues (Clayton et al., 2014; James et al., 2013, 2011; James, Mattin, Aldiss, Adebishi, & Hobson, 2014) as well had reported that the additional of protein/amino acid to carbohydrate electrolyte beverage enhanced rehydration process.

A urine sample was taken before the start of the dehydration exercise and a final urine sample was also collected for USG assessment. The results showed that there were no significant differences in the USG before exercise ($p=0.316$) and after the rehydration process ($p=0.542$). The participants had started the assessment in a well hydrated condition (USG <1.020) for both sessions. After 4 hours of the rehydration process, both beverages had the ability to rehydrate and produce urine that showed characteristics of being well hydrated (USG CE= 1.008 ± 0.006 ; *ZM*= 1.009 ± 0.003) (Armstrong, 2007; Chevront & Kenefick, 2014). This is important as the objective of the fluid consumption during rehydration is to replace fluid and electrolyte losses (Evans et al., 2017; Sawka et al., 2007; Shireffs & Maughan, 2000).

CONCLUSION

Zea mays juice has been shown to have a positive effect comparable to commercially available carbohydrate-electrolyte drink to rehydrate exercising athletes and to help them recover from the effects of the exercise. It showed that *Zea mays* juice could be one of the choices for a rehydration beverage.

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