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The effect of dilution on the erosive potential of maltodextrin-containing sports drinks

Efeito da diluição no potencial erosivo de bebidas esportivas contendo maltodextrina

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Resumo

Introdução: O consumo de bebidas esportivas contendo maltodextrina durante a atividade física tem aumentado. Geralmente elas são ácidas, podendo causar erosão dentária. **Objetivo:** Avaliar o efeito da diluição sobre o potencial erosivo de bebidas esportivas contendo maltodextrina. **Metodologia:** Cinco amostras de cinco bebidas esportivas contendo maltodextrina [Sports Nutrition (SN), Body Action (BA), New Millen (NM), Atlhetica Nutrition (AN), Integral Medica (IM)] foram diluídas com água destilada em três diferentes proporções: como recomendado pelo fabricante (REC), com 20% a mais de pó (20+) e com 20% a menos de pó (20-) do que o recomendado. Foram determinados o seu pH e titrabilidade ácida (volume de NaOH 1N necessário para elevar o pH para 5,5). **Resultado:** O pH e titrabilidade ácida foram diferentes entre os produtos. Os valores de pH foram diferentes entre as diluições. Todas as bebidas esportivas apresentaram pH abaixo do pH crítico para a desmineralização do esmalte dental. Houve uma correlação negativa significativa entre o pH e a titrabilidade ácida (p <0,01; r = -0,795). **Conclusão:** Pequenas alterações na diluição de bebidas esportivas contendo maltodextrina podem afetar o seu pH, mas não a sua titrabilidade ácida.

Descritores: Maltodextrina; bebidas esportivas; erosão dentária; pH; titrabilidade ácida.

Abstract

Introduction: The increasing consumption of maltodextrin-containing sports drinks, usually acidic, during physical activity may cause dental erosion. **Objective:** To evaluate the effect of dilution on the erosive potential of maltodextrin-containing sports drinks. **Methodology:** Five samples of five maltodextrin-containing sports drinks [Sports Nutrition (SN), Body Action (BA), New Millen (NM), Athletica Nutrition (AN), Integral Medica (IM)] were diluted with distilled water in three different proportions: as recommended by manufacturer (rec), with 20% more powder (20+) and with 20% less powder (20-) than recommended. Their pH and titratable acidity (volume of 1N NaOH necessary to raise pH to 5.5) were determined. **Result:** The pH and titratable acidity differed among the products, and pH values differed among the dilutions. All sports drinks showed pH below the critical pH for dental enamel demineralization. There was a significant negative correlation between pH and titratable acidity (p <0.01; r = -0.795). **Conclusion:** Changes in the dilution of maltodextrin-containing sports drinks affected their pH, but not their titratable acidity.

Descriptors: Maltodextrin; sports drinks; tooth erosion; pH; titratable acidity.

INTRODUCTION

Sports drinks are used in prolonged physical activities to reduce fatigue resulting from both the depletion of body glycogen stores and dehydration[1] that may be associated with impaired aerobic capacity, decreased plasma volume and increased body temperature. Based on these factors, sports drinks have specially-formulated solutions designed to hydrate the body and enhance performance by providing energy supplementation[2,3].

Athletes undergoing prolonged exercise generally use combined carbohydrate formulas to enhance carbohydrate and fluid delivery that may support exercise performance. It should be considered that these drinks have usually a low pH and variable titratable acidity and both of which are relevant to their potential to cause dental erosion[3-5].

Dental erosion, also denominated erosive tooth wear (ETW), is defined as a localized loss of hard dental tissue caused by acids not produced by microorganisms[6]. The origin of acids can be intrinsic (gastric acid) or extrinsic (e.g. acidic beverages). The consumption of manufactured beverages, which are usually acidic due to preservatives and acidulants, is a growing phenomenon in modern societies[7].

Since maltodextrin is a component of manufactured sport drinks that are usually consumed during exercise performance, when the oral cavity may be dehydrated and be less protected by the acquired pellicle from saliva, the risk of dental erosion could be increased[4,8].

The consumption of acidic drinks may cause dental erosion depending on the frequency and duration of exposure[5]. The alternatives to reduce their erosive potential are: lowering the concentration of acid preservatives; adding calcium, phosphate and fluoride ions, or acidity regulators[4,9]. However, these substances may bring an unpleasant taste[4]. Another alternative that has also been reported is their extra dilution with water, which has already been evaluated in fruit juices[10,11].

Furthermore, since variations in the dilution of sports drinks may occur during preparation, purposely or not, the aim of the present study was to evaluate whether different powder:water proportions of some maltodextrin-containing sports drinks could affect their erosive potential, represented by their pH and titratable acidity.

METHODOLOGY

Experimental Design

Five commercial brands of maltodextrin-containing sports drinks were evaluated (Chart 1) by the response variables: pH and titratable acidity. The factors under study were the commercial brands (five levels) and dilutions (three levels: as recommended by the respective manufacturer; with 20% more powder, and with 20% less powder than recommended). Both pH and titratable acidity were determined five times for each drink.

Five samples of each of the 5 tested sport drinks, in each of the 3 tested dilutions, were prepared. The maltodextrin powder, was weighed in an analytical balance (Digimed KN 500) according to studied proportions to obtain 100 ml of solution. The powder was added to 80 ml of cold water (5ºC) under agitation, and the final volume was adjusted to 100 ml in a volumetric balloon.

pH Determination

Fifty milliliters of each tested solution were added to a beaker. The pH was determined with a pH electrode (Sensoglass SC09), connected to a potentiometer (RbLAb), equipped with a temperature sensor. The electrode was previously calibrated with standard buffer solutions of pH 4.0 and 7.0.

Titratable Acidity Determination

After determining the pH, increments of 50 µL of 1N sodium hydroxide (NaOH) were added to each tested solution until pH = 5.5 was reached[12]. The volume of NaOH necessary for titration was recorded in mL. The value of pH = 5.5 was chosen considering the critical pH for enamel demineralization.

Statistical Analysis

The Levene test was used to evaluate the data distribution. The pH values were analyzed by 2-way ANOVA and Tukey tests. Titratable acidity was analyzed by the Kruskal-Wallis and Dunn Tests. The Spearman correlation between pH and titratable acidity was determined. The level of significance was set at 5%.

RESULT

Regarding the pH data, there was no statistically significant interaction between the factors commercial brand and dilution ($p = 0.072$). But there were statistically significant differences among the pH values of the different commercial brands and among the dilutions. The highest powder: water proportion (20+) presented the lowest pH of the solution (Table 1).

Regarding the titratable acidity data, the Kruskal-Wallis and Dunn tests considered 15 groups. There was statistically significant difference between some groups, with the most evident being between the commercial brands AN and IM. There was no difference among dilutions (Table 2).

Chart 1. Manufacturer, flavor, composition and recommended preparation of the sports drinks evaluated

Group	Manufacturer (Flavor)	Composition	Recommended preparation
SN	Sports Nutrition (lemon)	Maltodextrin (96%), glucose, flavoring, citric acid.	50g of powder to 250 mL of water
BA	Body Action (orange and acerola)	Maltodextrin (96%), sucrose, flavoring, dye, citric acid.	50g of powder to 250 mL of water
NM	New Millen (tangerine)	Maltodextrin (96%), flavoring, soy lecithin stabilizer, tricalcium phosphate, citric acid.	50g of powder to 300 mL of water
AN	Athletica Nutrition (açai and guarana)	Maltodextrin (95%), aspartame (75mg/100g) and Acesulfame Potassium (35mg/100g), colorants.	40g of powder to 250 mL of water
IM	Integral Medica (guarana)	Maltodextrin (94%), sucralose, flavoring, colorants, tricalcium phosphate.	50g of powder to 250 mL of water

Table 1. pH values (mean ± SD) of maltodextrin-containing sports drinks, in different proportions: as recommended by manufacturer (rec), with 20% more powder (20+) and with 20% less powder (20-) than recommended

Group	rec	20+	20-	Mean
SN	2.84 ± 0.05 B	2.74 ± 0.05 B	2.84 ± 0.05 B	**2.81 ± 0.07 B**
BA	2.68 ± 0.04 C	2.64 ± 0.05 C	2.80 ± 0.07 C	**2.71 ± 0.09 B**
NM	2.68 ± 0.04 CD	2.64 ± 0.05 CD	2.66 ± 0.09 CD	**2.66 ± 0.09 CD**
AN	2.66 ± 0.05 D	2.58 ± 0.04 D	2.66 ± 0.05 D	**2.63 ± 0.05 D**
IM	4.51 ± 0.04 A	4.41 ± 0.04 A	4.50 ± 0.02 A	**4.47 ± 0,02 A**
mean	**3.07 ± 0.73 b**	**3.00 ± 0.72 c**	**3.09 ± 0.72 a**	

Values followed by distinct letters indicate statistically significant difference ($p < 0.01$; capital letters compare products and lower case letters compare proportion).

Table 2. Titratable acidity values (median) of maltodextrin-containing sports drinks, in different proportions: as recommended by manufacturer (rec), with 20% more powder (20+) and with 20% less powder (20-) than recommended

Group	rec	20+	20-
SN	2.90 ABC	3.75 ABC	2.20 ABC
BA	2.15 ABC	2.55 ABC	1.80 BC
NM	3.90 ABC	4.80 AB	3.25 ABC
AN	5.25 A	6.35 A	4.30 AB
IM	0.35 C	0.45 C	0.30 C

Values followed by distinct letters indicate statistically significant difference ($p < 0.05$; the Kruskal-Wallis and Dunn tests).

There was significant negative correlation between pH and titratable acidity (Spearman; $p < 0.01$; $r = 0.795$).

DISCUSSION

This study evaluated the effect of dilution on the erosive potential of maltodextrin-containing sports drinks. According to the literature, the factors defining the erosive potential of a substance are: high frequency of intake, low pH, high titratable acidity and low concentration of calcium, phosphate and fluoride. It has been pointed out that these factors should not be considered alone. For example, an acid drink may not have potential to cause dental erosion if it contains a large quantity of calcium (a protective factor), as is the case of yoghurts. The low pH and high titratable acidity are considered the main risk factors[5].

The pH values between 2.6 and 2.8, for the sports drinks evaluated, except for IM, which was around 4.5 (Table 1), were similar to the pH values reported for soft drinks and processed juices[13]. When the results between the brands evaluated were compared, differences were found; the IM brand showed the highest pH. When the product labels were assessed, it was found that both IM and AN did not contain citric acid, which was present in the other three brands (Table 1). Citric acid is often added to drinks as acidulant to enhance their acid taste[14], making them refreshing drinks.

There was also a significant difference in pH between different dilutions, and the higher the proportion of powder, the lower the pH of the product. Thus, increasing the dilution of the drink could increase the pH (Table 1). This has also been reported for fruit juices[11], but has not been verified by others[10].

However, it is important to note that all beverages in all tested dilutions had pH values below the critical value for tooth enamel demineralization (5.5). Considering dentin, whose critical pH for demineralization is equal to 6.5, the erosive potential would be even greater. In spite of the significant difference between the pH values, the authors believed that all the beverages and their proportions evaluated (except IM) would cause a tooth mineral loss, since a limit to the relationship between pH and tooth demineralization was demonstrated, whereas below pH 2.9, demineralization followed a similar pattern[15].

Regarding titratable acidity, this method was considered a more realistic way of predicting erosive potential than pH, since pH only provided a measure of the initial hydrogen ion concentration, while titratable acidity considered hydrogen dissociation of the acids[16]. In addition, the titratable acidity of a beverage had a greater influence on the salivary pH than its pH had[17].

Titratable acidity depends on the concentration and force of the acid. SN, BA and NM contained citric acid, as reported on their label (Chart 1). Citric acid is a weak acid that partially dissociates, thus forming a pH buffer system. Being tricarboxylic, it can dissociate into three hydrogen ions, with three pKa values: $pKa_1 = 3.13$; $pKa_2 = 4.76$; $pka_3 = 6.40$. This results in the presence of three different buffering areas: between pH 2.13 and 4.13; 3.76 and 5.76; and 5.40 and 7.40, respectively[18]. Therefore, all the pH values of the drinks evaluated, even in different dilutions, were within the buffering range of citric acid. This meant that the citric acid would donate hydrogen ions to the medium to neutralize hydroxyls (sodium hydroxide) added during the titratable acidity test. In other words, by changing the dilution of the product, its pH was altered through changing the concentration of available hydrogen ions (Table 1). But this dilution was unable to change the titratable acidity of the drinks (Table 2), since the pH was maintained within the buffering range of citric acid.

However, increasing the dilution of juices has been reported to decrease their titratable acidity[10,11]. Although this was not followed by a decrease in the erosive demineralization of the enamel surface[11], it should be noted that the juices in these studies were diluted to higher extent than the sports drinks in the present study were, precisely for the purpose of preparing prepare a drink with less erosive potential. However, in these cited studies, the extra dilution was questioned, since the diminished taste would not be approved by the consumer[10,11]. In the present study, changes in dilutions (only 20%) were made considering the variations that naturally occur during the preparation of these drinks.

Finally, considering the results, the authors could assume that the change in the proportion indicated by the manufacturer could affect the pH of the sports drinks evaluated. But, in the oral cavity, the acid buffering capacity would not be influenced. Therefore, athletes can prepare maltodextrin without worrying about increasing their erosive potential. However, it would be interesting for athletes to be aware that the pH of this sports drink was below the critical value for enamel (5.5) and dentin (6.5) demineralization and could increase the risk for the development of dental erosion.

CONCLUSION

Changes in the dilution of maltodextrin-containing sports drinks affected their pH, but not their titratable acidity.

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CONFLICTS OF INTERESTS

The authors declare no conflicts of interest.

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