

นิพนธ์ต้นฉบับ

การยอมรับของสารละลายเกลือแร่ที่ใช้น้ำตาลมะพร้าวในผู้ป่วยเด็กโรคอุจจาระร่วงเฉียบพลัน

ชญาณิศ ธนฤกษ์ชัย¹, สวงนศักดิ์ ฤกษ์สุภผล¹, ลัคนา ฤกษ์สุภผล²

¹ภาควิชากุมารเวชศาสตร์ คณะแพทยศาสตร์ มหาวิทยาลัยศรีนครินทรวิโรฒ จังหวัดนครนายก ประเทศไทย

²ภาควิชาเวชศาสตร์ป้องกัน คณะแพทยศาสตร์ มหาวิทยาลัยศรีนครินทรวิโรฒ จังหวัดนครนายก ประเทศไทย

Received May 20, 2026 Revised September 24, 2026 Accepted September 29, 2026

บทคัดย่อ

ความเป็นมา: การยอมรับด้านรสชาติเป็นปัจจัยสำคัญต่อความร่วมมือในการรับประทานสารละลายเกลือแร่สำหรับทดแทนสารน้ำทางปาก โดยเฉพาะในเด็กที่มีโรคอุจจาระร่วงเฉียบพลัน ซึ่งรสชาติที่ไม่เป็นที่ยอมรับอาจจำกัดปริมาณสารละลายที่เด็กสามารถรับประทานได้ น้ำตาลมะพร้าวเป็นแหล่งคาร์โบไฮเดรตจากธรรมชาติที่มีรสชาติเฉพาะและมีการบริโภคอย่างแพร่หลาย

วัตถุประสงค์: เพื่อเปรียบเทียบการยอมรับของสารละลายสำหรับการทดแทนสารน้ำทางปากชนิดน้ำตาลมะพร้าวกับสารละลายเกลือแร่มาตรฐานในเด็กที่มีโรคอุจจาระร่วงเฉียบพลัน

วิธีการศึกษา: การทดลองแบบสุ่ม มีกลุ่มควบคุม และปกปิดสองฝ่าย ในผู้ป่วยเด็กอายุน้อยกว่า 72 เดือน ที่มีโรคอุจจาระร่วงเฉียบพลันร่วมกับภาวะขาดน้ำเล็กน้อยถึงปานกลาง จำนวน 59 ราย สุ่มเป็นกลุ่มที่ได้รับสารละลายชนิดน้ำตาลมะพร้าว 28 ราย และสารละลายเกลือแร่มาตรฐาน 31 ราย ประเมินการยอมรับในระยะแรกและที่ 24 ชั่วโมงจากสีหน้าและพฤติกรรม ระดับความชอบ คะแนนการยอมรับ และความคิดเห็นของผู้ดูแล ส่วนปริมาณสารละลายที่ดื่ม การให้สารน้ำทางหลอดเลือดดำ ผลลัพธ์ทางคลินิก และผลตรวจทางห้องปฏิบัติการประเมินเป็นผลลัพธ์รองเชิงสำรวจ

ผลการศึกษา: ไม่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติของการยอมรับระหว่างสองกลุ่ม โดยสัดส่วนที่ประเมินว่า “ชอบ” จากแบบประเมินภาพใบหน้าเท่ากับร้อยละ 50.0 เทียบกับ 36.7 (p value 0.535) คะแนน Visual analogue scale (VAS) เฉลี่ย 68.3 ± 17.5 เทียบกับ 62.1 ± 20.4 มม. (p value 0.258) และผู้ดูแลประเมินว่าเด็ก “ชอบ” ร้อยละ 51.7 เทียบกับ 34.6 (p value 0.608) ในกลุ่มน้ำตาลมะพร้าวและกลุ่มมาตรฐานตามลำดับ ปริมาณสารละลายที่ดื่มใน 24 ชั่วโมงมีค่ามัธยฐาน 90 เทียบกับ 30 มล. (p value 0.988) และผู้ป่วยได้รับสารน้ำทางหลอดเลือดดำในปริมาณมากทั้งสองกลุ่ม ไม่พบเหตุการณ์ไม่พึงประสงค์ที่สัมพันธ์กับสารละลายที่ศึกษา

สรุป: การศึกษานี้ไม่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติด้านการยอมรับระหว่างสารละลายชนิดน้ำตาลมะพร้าวกับสารละลายเกลือแร่มาตรฐาน อย่างไรก็ตาม เนื่องจากปริมาณสารละลายที่ดื่มมีน้อยและผู้ป่วยได้รับสารน้ำทางหลอดเลือดดำในปริมาณมาก จึงไม่สามารถสรุปประสิทธิภาพในการทดแทนสารน้ำหรือความเท่าเทียมทางการรักษาของสารละลายทั้งสองชนิดได้ นอกจากนี้ยังไม่ได้ตรวจวัด osmolality และองค์ประกอบอิเล็กโทรไลต์ทั้งหมดของสารละลายชนิดน้ำตาลมะพร้าว จึงจำเป็นต้องมีการศึกษาเพิ่มเติมในอนาคตเพื่อจะเปรียบเทียบประสิทธิภาพของเกลือแร่จากน้ำตาลมะพร้าวและสูตรมาตรฐานในแง่การแก้ภาวะขาดน้ำได้มากขึ้น

คำสำคัญ: เด็ก, น้ำตาลมะพร้าว, โรคอุจจาระร่วงเฉียบพลัน, สารละลายเกลือแร่, รสชาติ

Acceptability of coconut sugar-based oral rehydration solution for children with acute gastroenteritis

Chayanit Thanalearkchai¹, Sanguansak Rerksuppaphol¹, Lakkana Rerksuppaphol²

¹Department of Pediatrics, Faculty of Medicine, Srinakharinwirot University, Nakhon Nayok, Thailand

²Department of Preventive Medicine, Faculty of Medicine, Srinakharinwirot University, Nakhon Nayok, Thailand

Abstract

Background: Palatability is an important determinant of adherence to oral rehydration therapy, particularly in children with acute gastroenteritis, as poor taste acceptability may limit the volume of oral rehydration solution consumed. Coconut sugar is a naturally derived carbohydrate source with a distinctive flavor profile and is widely consumed in Southeast Asia. These characteristics provide a rationale for investigating coconut sugar as an alternative carbohydrate source in an oral rehydration solution.

Objectives: To compare the acceptability of a coconut sugar-based rehydration solution with standard ORS in children with acute gastroenteritis, and to descriptively assess adverse events and exploratory clinical outcomes.

Methods: In this double-blind randomized controlled trial, 59 pediatric inpatients (<72 months) with mild-to-moderate dehydration were randomized to a coconut sugar-based rehydration solution (CO group; n= 28) or standard glucose-based ORS (SO group; n= 31). Acceptability was assessed initially and at 24 hours using researcher-observed responses, a facial hedonic scale, a visual analogue scale (VAS), and caregiver assessment. ORS intake, intravenous fluid administration, clinical parameters, and laboratory findings were analyzed as exploratory secondary outcomes.

Results: No statistically significant differences in acceptability were observed between groups. “Like” ratings on the facial hedonic scale were 50.0% in the CO group and 36.7% in the SO group (p value 0.535); mean VAS scores were 68.3 ± 17.5 versus 62.1 ± 20.4 mm (p value 0.258); and caregiver-reported “like” responses were 51.7% versus 34.6% (p value 0.608), respectively. Median 24-hour study-solution intake was low (90 vs 30 mL; p value 0.988), while substantial intravenous fluid was administered in both groups. No adverse events attributable to the study solutions were observed.

Conclusion: Measured acceptability did not differ significantly between the coconut sugar-based rehydration solution and standard ORS. Because oral intake was low and intravenous fluid administration was substantial, this study cannot establish comparative rehydration efficacy or therapeutic equivalence. In addition, the osmolality and complete electrolyte composition of the coconut sugar-based solution were not measured. Further formulation and clinical studies are required.

Key words: Child, Coconut, Gastroenteritis, Oral rehydration solution, Taste

Introduction

Acute gastroenteritis remains a significant public health burden in Thailand, disproportionately affecting children under five years of age. It consistently ranks as the nation's most prevalent infectious disease, with recent morbidity rates exceeding 1,800 per 100,000 population; approximately 25% of these cases occur in children under five.¹ Institutional data reflect this trend: a review of pediatric admissions at the Her Royal Highness Princess Maha Chakri Sirindhorn Medical Center (2019–2023) identified 4,282 cases of acute gastroenteritis, 64% of which involved patients under five years old.

Diarrheal illness causes rapid fluid and electrolyte losses, precipitating dehydration and metabolic imbalances.^{2,3} Because intestinal water absorption relies on the coupled co-transport of sodium with glucose, a mechanism preserved during acute diarrhea, oral rehydration solution (ORS) remains the cornerstone of therapy.⁴ For mild-to-moderate dehydration, the WHO and UNICEF recommend a standardized glucose-based ORS. However, poor palatability frequently results in treatment refusal among children, compromising adherence. Attempts to enhance flavor with fruit juices alter essential electrolyte composition and osmolality without improving clinical efficacy.⁵ Furthermore, limited access to ready-to-use sachets can delay early home administration.

To address accessibility barriers, the WHO and UNICEF support the preparation of homemade ORS using salt, sugar, and clean water.⁶ Additionally, alternative carbohydrate bases, such as rice⁷ or sucrose,⁸ have demonstrated comparable rehydration efficacy, as they hydrolyze into monosaccharides that facilitate sodium co-transport. Coconut sugar, a widely used natural sweetener in Southeast Asia, offers a highly palatable taste profile and contains beneficial micronutrients, including iron, zinc, and calcium.⁹ Despite its potential as a locally sustainable, value-added ingredient in Thailand, coconut sugar has not previously been evaluated as a carbohydrate source in pediatric ORS formulations.

Therefore, this study aimed primarily to compare the acceptability of a coconut sugar-based rehydration solution with standard glucose-based ORS in children with acute gastroenteritis and mild-to-moderate dehydration. Adverse events and clinical and biochemical outcomes were assessed as exploratory secondary outcomes. We hypothesized that the coconut sugar-based rehydration solution would demonstrate acceptable palatability in this pediatric population.

Objectives

To compare the acceptability of a coconut sugar-based rehydration solution with standard ORS in children with acute gastroenteritis and explore adverse events and clinical outcomes.

Methods

A randomized, double blind controlled trial was conducted in the Department of Pediatrics at the HRH Princess Maha Chakri Sirindhorn Medical Center, Faculty of Medicine, Srinakharinwirot University, Nakhon Nayok, Thailand from December 2024 to October 2025. The study protocol was approved by the Human Research Ethics Committee of Srinakharinwirot university (SWUEC-671007) . The trial was registered in the Thai Clinical Trials Registry (TCTR20250509004).

Children admitted to the pediatric ward with acute diarrhea and mild to moderate dehydration were eligible to participate. Acute diarrhea was defined as three or more episodes of loose or watery stools per day, with or without fever or vomiting, lasting fewer than two weeks.² Exclusion criteria included severe dehydration, severe systemic illness (e.g., congenital heart disease, liver/kidney disease, immunodeficiency, severe malnutrition), diagnosed or suspected surgical conditions, inability to tolerate oral intake, and age 7 years or older. Following written informed consent from parents or legal guardians, participants underwent a comprehensive medical history, physical examination, and baseline laboratory investigations (complete blood count, serum electrolytes, BUN, creatinine, stool, and urinalysis), which were repeated at 24 hours. Patient confidentiality was strictly maintained.

After baseline data collection, participants were randomly allocated using block randomization (via a computerized random number generator, GraphPad QuickCalcs) to ensure balanced allocation and minimize selection bias. The intervention group received a coconut sugar-based rehydration solution (CO) containing 3 g of coconut sugar and 0.5 g of sodium chloride per sachet, reconstituted with 150 mL of water. After reconstitution, these amounts corresponded to 20 g/L of coconut sugar and 3.33 g/L of added sodium chloride. Based on the molecular weight of sodium chloride (58.44 g/mol) , the added sodium chloride supplied approximately 57 mmol/L of sodium and 57 mmol/L of chloride. No potassium salt, citrate, or bicarbonate was added to the CO formulation. Because coconut sugar is not pure glucose and contains a mixture of carbohydrates, the exact glucose concentration and sodium-to-glucose molar ratio of the final solution could not be determined from the ingredient weights alone. The final electrolyte composition and osmolality of the

CO solution were not directly measured; therefore, the CO formulation was not assumed to be compositionally equivalent to the WHO reduced-osmolarity ORS (sodium 75 mmol/L, glucose 75 mmol/L, and total osmolarity 245 mOsm/L). The control group received commercially available standard oral rehydration salts (CERA®; Thai FDA registration no. 2A 52/54), also reconstituted with 150 mL of water as used in the study. Both solutions were dispensed in identical opaque bottles to maintain blinding of caregivers and study personnel involved in administration. Both study solutions were prepared by the hospital Nutrition Unit according to the study protocol and dispensed in identical opaque bottles. Preparation by a designated unit was used to standardize the formulation and reconstitution procedure across participants. No laboratory quality-control testing of the final osmolality or electrolyte concentrations was performed. Oral rehydration was prescribed according to the institutional protocol, with a target of 50-100 mL/kg during the initial four hours followed by approximately 10 mL/kg after each subsequent watery stool. Intravenous fluid therapy was permitted when clinically indicated, including inadequate oral intake, persistent vomiting, or failure to achieve adequate rehydration orally, according to the treating pediatrician's judgment. The volume and duration of intravenous fluid administration were recorded. Because a substantial proportion of total rehydration was delivered intravenously, subsequent clinical rehydration variables were considered exploratory secondary outcomes rather than direct measures of the efficacy of either oral solution.

The primary outcome was taste acceptability of the study solution. Acceptability was assessed at the initial administration and again at 24 hours using four complementary measures: a five-point facial hedonic scale, direct researcher observation of facial and behavioral responses using a 12-item observation checklist adapted from previously published pediatric behavioral assessment methods, a 10-cm visual analogue scale (VAS), and a three-point caregiver perception score.^{10,11} The facial hedonic scale and VAS were based on methods previously evaluated for pediatric medicine acceptability; however, the cited validation study primarily included children aged 2 years and older and did not report diagnostic sensitivity or specificity. Accordingly, sensitivity and specificity were not assumed for these instruments in the present study. For infants and children who were developmentally unable to provide reliable self-reported ratings, caregiver proxy assessment and immediate observed behavioral responses were used as supportive indicators of acceptance rather than as validated direct measures of taste preference. Observed facial or behavioral responses could also reflect illness-related discomfort, anxiety, or the hospital environment and were therefore

interpreted cautiously. All researcher-observed acceptability assessments were performed by a single researcher using the same predefined assessment procedure throughout the study. Because only one researcher performed these observations, inter-rater reliability was not applicable and was not assessed. Secondary outcomes included total ORS volume consumed, intravenous fluid volume and duration, stool frequency, duration of diarrhea, change in body weight, post-treatment biochemical parameters, occurrence of adverse events, and length of hospital stay. These secondary clinical outcomes were regarded as exploratory because intravenous fluid administration could independently influence hydration status, laboratory values, and recovery. Participants were followed until clinical recovery or for a maximum of seven days.

Sample study and calculation

Based on prior studies,¹² sample size was calculated to detect an increase in acceptability from 38 percent with standard ORS to 76 percent with coconut sugar based ORS. Achieving 80 percent power at a two sided 0.05 significance level required 25 children per group. Adjusting for a 15 percent withdrawal rate, the final sample size was set at 58 participants, or 29 per group.

Statistical analysis

Data were analyzed using IBM SPSS Statistics 23.0. A p value of < 0.05 was considered statistically significant. Categorical variables (sex, degree of dehydration, ORS acceptability) were summarized as frequencies and percentages. Continuous variables (age, weight, vital signs, serum electrolytes) were presented as means with standard deviations (SD) or medians with interquartile ranges (IQR), depending on distribution. Comparative analyses were performed using the chi-square test or Fisher's exact test for categorical variables, and the independent t-test or Mann-Whitney U test for continuous variables. Correlations between caregiver perception, hedonic scale, and visual analogue scale were analyzed using Kendall's tau-b correlation coefficient, where absolute values < 0.2 indicate weak associations, $0.2-0.3$ indicate moderate associations, and ≥ 0.3 indicate strong associations.¹³

Results

Of the 71 children assessed for eligibility, 60 participants were enrolled in the trial and randomized into two treatment groups. One participant in the coconut sugar-based ORS (CO) group was excluded from the final analysis due to incomplete records of ORS taste acceptability. The flow chart of the enrollment

process and procedure is shown in Figure 1. Among the 60 participants, 30 (50%) were boys and the median age (range) was 27.5 months (1- 71 months). There were no statistically significant differences in baseline characteristics and laboratory parameters between groups, except for serum creatinine level (Table 1).

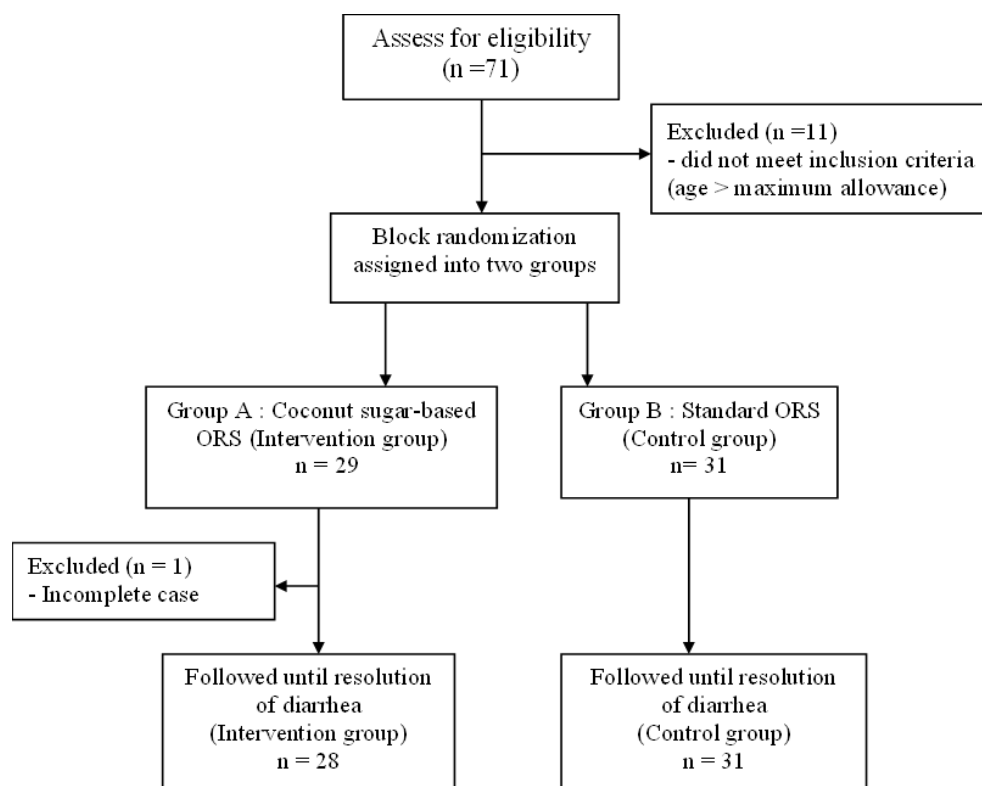


Figure 1 Consort flow diagram

Primary outcome

Facial expressions and behavioral responses at the first administration of ORS are presented in Figure 2. At least one facial or behavioral reaction was observed in 78.6% of participants in the coconut sugar-based ORS (CO) group and 80.6% in the standard ORS (SO) group. There were no statistically significant differences in any individual facial and behavioral responses between two groups (p value 0.843). Based on the facial hedonic scale, 50.0% of children in the CO group and 36.7% in the SO group rated the solution as “like,” while “neutral” ratings were reported in 30.8% vs 33.3%, and “dislike” ratings in 19.2% vs 30.0%, respectively (p value 0.535).

Table 1 Demographic data, baseline characteristics and laboratory findings of the enrolled participants prior to the initiation of treatment.

Variables	coconut sugar-based group (n=29)	standard glucose-based group (n=31)	p value
Age, months	20.0 (32.0)	31.5 (43.0)	0.255
Boy, n (%)	16.0 (55.0)	14.0 (45.2)	0.438
Weight, kg	11.6 ± 4.6	13.0 ± 4.9	0.239
Height, cm	83.0 (32.4)	87.5 (32.8)	0.430
Vomiting, n (%)	22.0 (75.9)	21 (67.7)	0.485
Pre-enrolled vomiting duration, hour	7.5 (33.0)	4.0 (24.0)	0.325
Numbers of vomiting before enrollment, n	2.0 (4.0)	3.0 (5.0)	0.869
Pre-enrolled diarrhea duration, hours	24.0 (44.0)	24.0 (42)	0.902
Stool frequency, n	5.0 (9.0)	4.0 (5.0)	0.202
Body temperature, °C	37.5 (0.9)	37.2 (1.4)	0.411
Heart rate, bpm	136.9 ± 19.3	133.6 ± 19.5	0.515
Lab before treatment			
Hemoglobin, g/dL	12.0 (1.8)	11.7 (1.4)	0.706
Hematocrit, %	34.6 ± 3.3	35.0 ± 3.3	0.644
White blood cell, x10 ⁹ /L	12.10 (6.41)	11.90 (5.20)	0.779
Neutrophil, %	64.2 (24.5)	64.0 (28.7)	0.923
Platelet, µL	349103 ± 97337	356129 ± 114176	0.799
Sodium, mmol/L	135.2 ± 1.7	136.0 ± 1.9	0.084
Potassium, mmol/L	4.2 ± 0.5	4.0 ± 0.5	0.072
Chloride, mmol/L	102.0 ± 5.0	101.0 ± 2.0	0.468

Variables	coconut sugar-based group (n=29)	standard glucose-based group (n=31)	p value
Bicarbonate, mmol/L	17.9 ± 3.2	17.9 ± 2.4	0.963
Blood urea nitrogen, mg/dL	12.5 (7.7)	13.1 (10.1)	0.141
Creatinine, mg/dL	0.31 (0.07)	0.36 (0.15)	0.022

Data are presented as mean ± standard deviation, n (%) or median (interquartile range)

At the second observation, acceptability patterns of ORS intake were comparable between groups (Figure 3). Facial and behavioral responses were 78.6% vs 80.6% of participants in the CO group and the SO group (p value 0.843). On the facial hedonic scale, the CO group and the SO group rated the solution as “liked” in 50.0% and 36.7% of participants, respectively. Neutral ratings were reported in 30.8% and 33.3%, while “disliked” ratings were observed in 19.2% and 30.0% of participants, respectively (p value 0.535). The mean VAS score (mm) was higher in the coconut sugar-based ORS group (68.3 ± 17.5 mm) than in the standard ORS group (62.1 ± 20.4 mm), although the difference was not statistically significant (p value 0.258). Based on the caregiver’s perception questionnaire, 51.7% of caregivers in the CO group and 34.6% in the SO group reported that the child “liked” the ORS (p value 0.608). Caregivers’ perceptions of acceptability demonstrated strong positive correlations with the facial hedonic scale at the first observation ($r = 0.518$; p value < 0.01) and the second observation ($r = 0.37$; p value < 0.01), and a strong negative correlation with the visual analogue scale ($r = -0.685$; p value < 0.01)

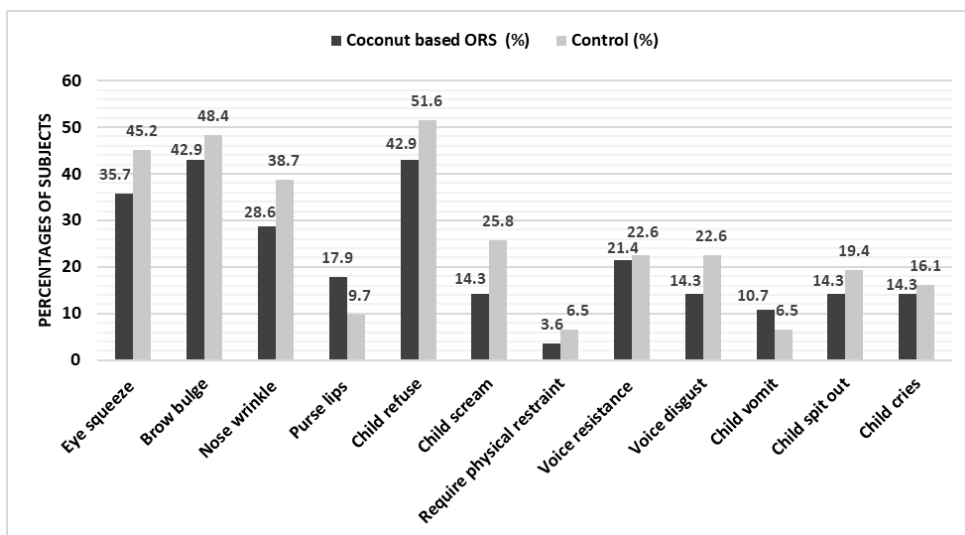


Figure 2 Percentages of facial expression and behavioral responses exhibited by participants during the first observation of oral rehydration solution (ORS)

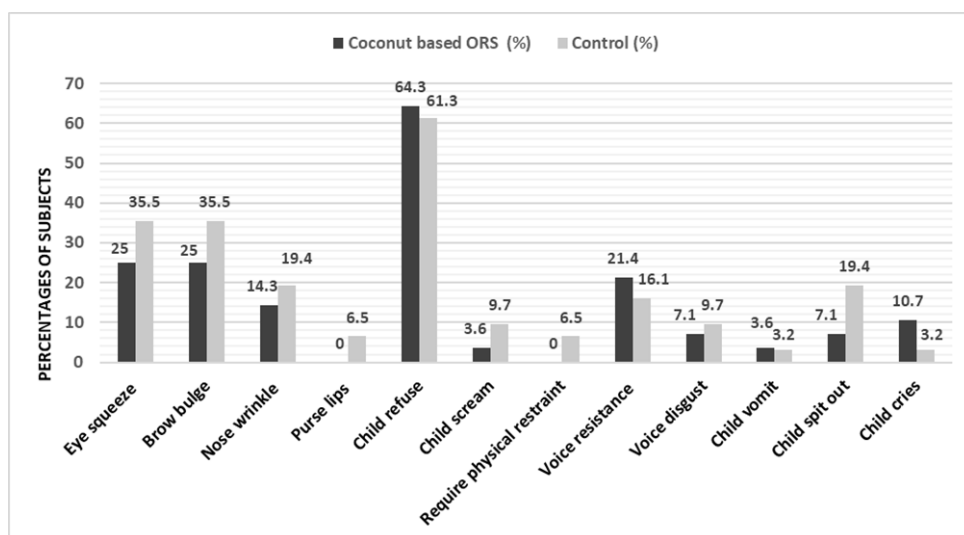


Figure 3 Percentages of facial expression and behavioral responses exhibited by participants during the second observation of oral rehydration solution (ORS)

Secondary outcome

Secondary outcome data are presented in Table 2. At the first 4 hours after administration, median ORS intake was 20.0 mL (IQR 95.0) in the CO group and 15.0 mL (IQR 35.0) in the SO group (p value 0.583). At second, median ORS consumption was 90.0 mL (IQR 224.0) and 30.0 mL (IQR 190.0), respectively (p value 0.988). When adjusted for body weight, ORS intake per kg was 5.6 mL/kg (IQR 14.2) in the CO group and 2.9 mL/kg (IQR 17.4) in the SO group (p value 0.912).

Table 2 Treatment outcomes in children with acute gastroenteritis receiving two groups of oral rehydration solution (ORS)

Variables	coconut sugar-based group (n=28)	standard glucose-based group (n=31)	p value
ORS intake (mL)			
Intake in 4 hours	20.0 (95.0)	15.0 (35.0)	0.583
Intake in 24 hours	90.0 (224.0)	30.0 (190.0)	0.988
Average intake in 24 hours, mL/kg	5.6 (14.2)	2.9 (17.4)	0.912
Intravenous fluid (IV)			
Volume in 24 hours, mL	1229.4 ± 447.7	1286.0 ± 378.4	0.598
Total in admission, mL	1782 (1033.0)	1883 (719.0)	0.728
Duration of IV administration, hour	32.5 (14.7)	34.3 (13.9)	0.554
Number of diarrheal stool, time/day	7.0 (8.0)	5.0 (7.0)	0.291
Duration to recovery from diarrhea, hour	34.2 (17.9)	33.0 (23.6)	0.790
Duration of admission, hour	51.0 (24.0)	47.3 (28.0)	1.000
Laboratory after treatment			
Sodium, mmol/L	138.7 ± 1.8	139.2 ± 2.6	0.425
Potassium, mmol/L	3.7 ± 0.5	3.8 ± 0.4	0.914
Chloride, mmol/L	106.0 ± 4.0	106.0 ± 4.0	0.517
Bicarbonate, mmol/L	20.9 ± 2.1	20.2 ± 2.8	0.232
Blood urea nitrogen, mg/dL	2.9 (3.8)	3.9 (2.9)	0.428
Creatinine, mg/dL	0.25 (0.06)	0.27 (0.07)	0.276
Weight at discharge, kg	11.6 ± 4.4	13.0 ± 4.7	0.223
Weight change, kg	0.2 (0.52)	0.3 (0.51)	0.260

Data were presented as mean ± standard deviation or median (interquartile range)

Other treatment outcomes were also comparable between groups, including total intravenous fluid volume and duration of infusion, stool frequency, duration of diarrhea and length of hospital stay. At 24 hours after treatment, laboratory parameters showed no dysnatremia or hypokalemia, with no statistically significant differences observed between the two groups. Median weight change during admission was 0.2 kg (IQR 0.52) in CO group and 0.3 kg (IQR 0.51) in SO group (p value 0.260). No adverse events were reported in either group.

Discussion

To our knowledge, this randomized controlled trial is the first to evaluate the acceptability of a coconut sugar-based rehydration solution compared with standard glucose-based ORS in children with acute gastroenteritis and mild-to-moderate dehydration. No statistically significant differences were observed in the prespecified acceptability measures, and no adverse events were observed in either group. Clinical and biochemical outcomes were considered exploratory because oral intake of the study solutions was low and intravenous fluid contributed substantially to rehydration.

Acceptability is an important determinant of adherence to oral rehydration therapy, particularly in young children who may refuse ORS because of palatability.⁵ In this study, it was evaluated using complementary measures, including facial and behavioral observations, a five-point facial hedonic scale, a visual analogue scale (VAS), and caregiver-reported perception. The hedonic scale and VAS were based on methods previously evaluated for pediatric medicine acceptability.¹⁰ However, standardized, age-appropriate methods remain limited in very young children who cannot reliably self-report.¹⁴ Accordingly, caregiver reports and behavioral observations were used to complement self-reported measures. These measures should be interpreted collectively, particularly in children younger than 2 years, as behavioral responses may also reflect illness-related discomfort, anxiety, or hospitalization.

Coconut sugar was selected as a locally available carbohydrate source with a distinct taste profile.⁹ A previous randomized trial involving 437 non-dehydrated children under five years of age found no significant improvement in acceptability of rice-based or flavored ORS compared with standard glucose ORS, with reported intake of 44–54 mL/kg/24 h.¹⁵ In contrast, oral intake in our study was considerably lower, with median intakes of 20 versus 15 mL during the first 4 hours and 90 versus 30 mL during 24 hours in the CO

and SO groups, respectively. Thus, the absence of a significant difference in acceptability should be interpreted in the context of the limited study-solution intake.

Although clinical and biochemical outcomes did not differ significantly between groups, these findings cannot establish comparative rehydration efficacy because most fluid replacement was provided intravenously. Furthermore, the osmolality and complete electrolyte composition of the coconut sugar-based solution were not measured, and its sodium-to-glucose molar ratio could not be determined. Therefore, therapeutic or biochemical equivalence to standard or WHO reduced-osmolality ORS cannot be assumed. Nevertheless, the present findings provide preliminary acceptability data that may inform further development and evaluation of coconut sugar-based oral rehydration formulations.

Strengths and limitations

A major strength of this study is its randomized, double-blind design and the use of multiple complementary measures of acceptability. Several limitations should be acknowledged. First, the relatively small sample size may have limited the ability to detect modest differences in acceptability. Second, oral intake of the study solutions was low, while intravenous fluid contributed substantially to rehydration, limiting interpretation of the clinical and biochemical outcomes. Third, the final osmolality and complete biochemical composition of the coconut sugar-based solution were not measured, and no laboratory quality-control testing of the prepared solutions was performed; therefore, equivalence to standard or WHO reduced-osmolality ORS cannot be assumed. Fourth, the acceptability measures were not validated across the entire age range, particularly in children younger than 2 years, and behavioral responses may have been influenced by factors other than taste. In addition, assessments were performed by a single researcher, precluding evaluation of inter-rater reliability. Finally, the etiology of diarrhea was not investigated and may have influenced oral intake and clinical recovery. Future studies should characterize the formulation and evaluate acceptability using age-appropriate validated measures, with efficacy assessed under protocols that minimize or control for intravenous fluid exposure.

Conclusions

In conclusion, the coconut sugar-based rehydration solution was acceptable to children with acute gastroenteritis and mild-to-moderate dehydration, with no significant difference in measured acceptability compared with standard ORS and no adverse events observed in either group. These findings provide preliminary evidence supporting further investigation of coconut sugar as a locally available carbohydrate

source for pediatric oral rehydration formulations. However, the low oral intake, substantial use of intravenous fluids, and lack of direct measurement of osmolality and electrolyte composition preclude conclusions regarding therapeutic equivalence or rehydration efficacy. Further studies should optimize and characterize the formulation and evaluate its acceptability and clinical performance in larger pediatric populations.

References

1. Charoenwat B, Suwannaying K, Paibool W, Laoaroon N, Sutr S, Thepsuthammarat K. Burden and pattern of acute diarrhea in Thai children under 5 years of age: A 5-year descriptive analysis based on Thailand National Health Coverage (NHC) data. *BMC Public Health*. 2022;22:1161.
2. World Health Organization: WHO. Diarrhoeal disease [Internet]. 2024 [cited 2025 Jan 21]. Available from: <https://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease>
3. World Health Organization. The treatment of diarrhoea: A manual for physicians and other senior health workers. 4th rev. ed. Geneva: World Health Organization; 2005.
4. Hagbom M, Svensson L. Rotavirus disease mechanisms. Elsevier eBooks [Internet]. 2016 [cited 2025 April 25] ;189–218. Available from: <https://www.sciencedirect.com/topics/nursing-and-health-professions/sodium-glucose-cotransporter-1#chapters-articles>
5. Te Loo DM, van der Graaf F, Tjon A Ten W. The effect of flavoring oral rehydration solution on its composition and palatability. *J Pediatr Gastroenterol Nutr*. 2004;39:545–8.
6. World Health Organization, UNICEF. Oral rehydration salts: Production of the new ORS. Geneva: World Health Organization; 2007.
7. Fontaine O, Gore SM, Pierce NF. Rice-based oral rehydration solution for treating diarrhea. *Cochrane Database Syst Rev*. 2000;:CD001264.
8. Faruque AS, Mahalanabis D, Hamadani JD, Hoque SS. Hypo-osmolar sucrose oral rehydration solutions in acute diarrhoea: A pilot study. *Acta Paediatr*. 1996;85:1247-8.
9. Saraiva A, Carrascosa C, Ramos F, Raheem D, Lopes M, Raposo A. Coconut sugar: Chemical analysis and nutritional profile, health impacts, safety and quality control, food industry applications. *Int J Environ Res Public Health*. 2023;20:3671.
10. Mistry P, Stirling H, Callens C, Hodson J, Batchelor H, project SP-U. Evaluation of patient-reported outcome measurements as a reliable tool to measure acceptability of the taste of paediatric medicines in an inpatient paediatric population. *BMJ Open*. 2018;8:e021961.

11. Katz ER, Kellerman J, Siegel SE. Behavioral distress in children with cancer undergoing medical procedures: developmental considerations. *J Consult Clin Psychol.* 1980;48:356-65.
12. CHOICE Study Group. Multicenter, randomized, double-blind clinical trial to evaluate the efficacy and safety of a reduced osmolarity oral rehydration salts solution in children with acute watery diarrhea. *Pediatrics.* 2001;107:613-8.
13. Fey CF, Hu T, Delios A. The measurement and communication of effect sizes in management research. *management and organization review.* 2023;19:176–97
14. Turner-Bowker DM, An Haack K, Krohe M, Yaworsky A, Vivas N, Kelly M, et al. Development and content validation of the Pediatric Oral Medicines Acceptability Questionnaires (P-OMAQ): Patient-reported and caregiver-reported outcome measures. *J Patient Rep Outcomes.* 2020;4:80.
15. Saniel MC, Zimicki S, Carlos CC, Maria AC, Balis AC, Malacad CC. Acceptability of rice-based and flavoured glucose-based oral rehydration solutions: A randomized controlled trial. *J Diarrhoeal Dis Res.* 1997;15:47-52.