BIOCHEMICAL ASSESSMENT OF HOME MADE FLUIDS AND THEIR ACCEPTABILITY IN THE MANAGEMENT OF DIARRHEA IN CHILDREN IN THE GEZIRA STATE, SUDAN

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هدف الدراسة : تهدف هذه الدراسة لإعداد محاليل منزلية مفيدة ، سهلة التحضير لمعالجة الإسهال عند الأطفال السودانيين بولاية الجزيرة وسط السودان .
طريقة الدراسة : المحاليل التي أجريت عليها الدراسة هي محلول الذرة المعروف بالنشا ومحلول الأرز أو ماء الأرز . أخذت عينة من النشا و 10 عينات من ماء الأرز من المنازل وأجريت عليها القياسات التالية : الأس الهيدروجيني و الكاربوهيدرات والدهون و الألياف و الرماد و الصوديوم والبوتاسيوم والكلورايد .
نتيجة الدراسة : وجد أن كل من محلول الذرة (النشا) ومحلول الأرز (ماء الأرز) يحوي كميات معتبرة من المواد الغذائية مما يجعل لهذين المحلولين قيمة غذائية . وقد وجد أن نسبة الصوديوم والكلوريد أقل من محتويات المحلول المقترح من هيئة الصحة العالمية واليونسيف ، ووجد أنه يمكن تعديل تكوين محلول النشا ومحلول الأرز بإضافة كلوريد الصوديوم ليشابه تكوين محلول الأرواء بالفم القياسي المقدم من هيئة الصحة العالمية واليونسف ، ويمكن ذلك بإضافة 3- 5و3 جرام كلوريد الصوديوم إلى لتر من محلول الذرة (النشا) وإضافة 3و2 – 6و2 جرام من كلوريد الصوديوم إلى لتر من محلول الأرز (ماء الأرز) .
الخلاصة : نخلص من هذه الدراسة بأن محلول الذرة (النشا) ومحلول الأرز (ماء الأرز) يمكن استعمالهما لمكافحة الجفاف ويمكن أيضا استعمالهما بعد إضافة كلوريد الصوديوم لمعالجة الجفاف الناتج من الإسهال كبديل لمحلول الأرواء بالفم القياسي ، وسيساعد ذلك في حل مشكلة عدم توفر المحلول مما يؤدي إلي خفض المراضة والوفيات بسبب الإسهال .

الكلمات المرجعية : نشا الذرة ، ماء الأرز ، الجفاف ، محلول الارواء بالفم .

Objectives: *To determine the biochemical constitution of homemade fluids and assess their acceptability and efficacy for the management of acute diarrhea in Sudanese children.*
Material and Methods: *This is a cross-sectional study of 150 children selected randomly. The fluids studied were 36 samples of sorghum-based solutions (nasha) and 10 samples of rice water. Samples were randomly collected from households and analyzed to determine the pH, carbohydrates, proteins, fat, crude fiber, ash and electrolytes (Na^+, K^+ and Cl^-).*
Results: *In addition to being very useful for rehydration, the two fluids were found to contain considerable amounts of nutrients. The sodium and chloride contents of homemade fluids were found to be much lower than those of the WHO/UNICEF ORS (oral rehydration solution). These electrolytes can be adjusted by adding table salt (3-3.5 g NaCl to one litre of sorghum-based solution and 2.3-2.6 g NaCl to one liter*

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of rice water) to bring them to concentration comparable to that of the standard ORS.

Conclusion: *Homemade solutions can be modified by adding table salt to bring them to the standard ORS and can be used successfully to prevent dehydration. This will solve the problem of the availability of ORS and reduce morbidity and mortality from diarrhea.*

Key Words*: Acute diarrhea, dehydration, sorghum gruel, rice-water, ORS, Sudan.*

INTRODUCTION

Acute diarrhea is a major cause of morbidity and mortality in young children all over the world. It is estimated that more than one billion episodes of acute diarrhea occur yearly in children in the developing world including Sudan.[1] In 1900, it was estimated that 23% of all deaths of children under five, in the developing countries, were caused by diarrhea.[2,3] A national survey in 1996 by the Diarrhoeal Disease Control Programme (CDD) in the northern states of Sudan showed a prevalence rate of 22% in the two weeks preceding the survey.[4]

Orally administered fluids and electrolyte solutions have been effectively used world-wide to treat children with acute diarrhea.[5] The physiologic basis for these solutions is the transport of glucose and/ or other organic solutes together with sodium to achieve enhanced absorption of salt and water.[6]

The impact of oral rehydration solution (ORS) on dehydration case/fatality rate, and cost effectiveness is well documented.[7-9] However, many logistic and economic problems limit the availability and distribution of ORS to less than half the population of the developing world.[10] Besides, since ORS does not reduce the volume, frequency or duration of diarrhea,[11] a frequently-mentioned source of dissatisfaction for mothers (and consequently for health care providers), there is a persistent desire to use antidiarrheal drugs and limit the amount of fluids given to dehydrated children. Cultural acceptance has often limited the use of ORS. The WHO estimates that <25% who could benefit from therapy are treated with ORS.[12] The rate of ORS use is only 31%.

One proposed approach for the development of an improved ORS, is to replace glucose, with glucose polymers e.g. d. hexoses, L. amino acids and their di- and tri- peptide forms.[13] This makes it possible to increase the amount of glucose in the ORS formulation without increasing its osmolarity.

The purpose of this research was to assess some locally used, primarily homemade fluids in the form of simple starch, containing glucose and di- and tri-peptides. These are readily available, easily prepared, have no adverse effects on children with diarrhea, and are culturally accepted by mothers.

MATERIAL AND METHODS

This is a cross-sectional house-to-house study. From Wad Medani (urban) and El Meilig (rural), central Sudan, 150 children aged 0-5 years, with diarrhea in the last 48 hours prior to the conduct of the study, were recruited by systematic random sampling. A questionnaire was used to determine the types and amounts of homemade fluids used for diarrhea, their methods of preparation, their effect on the status of dehydration and on the stool output, and the readiness with which the fluids were accepted by the children. The children were interviewed in their own homes by physicians and faculty

members of Gezira University. The informants were their mothers. A sub-sample of 36 specimens of sorghum-based solution (nasha) and 10 of rice water, the commonest fluids used, were obtained at random from the children's own homes, for laboratory analysis. The number of sub-samples was small on account of the limited resources available.

"Nasha" is a thin gruel, prepared from different varieties of sorghum flour. Approximately 130-135 grams of the flour is mixed with 300-400ml of water, left overnight to ferment, after which water is added to bring it up to 1000-1200ml. The solution is then decanted and boiled to a thin gruel to which 10 to 15g of sugar is usually added.

Rice water is prepared by soaking about 120-130g of rice in 300-400ml of water for 1 to 2 hours, and then manually crushing it. One liter of water is added to it and decanted, after which 2.5 – 5g of sugar is usually added. Both solutions are administered orally. 100ml/kg body weight is given during the first 4 hours. The condition of the child is then re-assessed and management continues with breast-feeding if there is improvement. If the condition has deteriorated, the child is referred to the hospital for i/v rehydration and resuscitation if necessary.

The samples were analyzed in duplicate, to determine their pH, electrolyte content (Na^+, K^+ and Cl^-) and to proximate analysis. The pH was measured using Philip's PW 9410 Digital pH-meter. Moisture was determined by the vacuum oven method described by the Association of Official Analytical Chemists (AOAC, 1990).[14] Protein contents were determined by the standard Kjedldahl method. Fat, ash, and crude fiber values were determined according to the AOAC (1990) methods. Sodium and potassium amounts were determined by flame photometry using the Corning 400-flame photometer.[14] The gravimetric method described by AOAC (1990) was used to determine chloride contents. A pschnometer or density bottle was used to measure specific gravity. The means and standard deviations were determined. More accurate and sensitive quantitative methods could have been used, but the methods used were the only ones available to the authors. However, the authors believe that the methods used, despite their limitations, were appropriate for the purpose of this study.

Improvement in the general condition of the child is assessed by the duration of diarrhea, stool consistency and increase in body weight.

The SPSS package was used for the analysis of data.

RESULTS

Table 1 shows the general characteristics of the study group. Rural children comprised 52.7%, and urban children 47.3%. Those of low socioeconomic status comprised 47.3%, middle class 38.7%, and of high socioeconomic status 14%. Of the mothers, 32.7% were illiterate.

Table 2 shows the types of early management of diarrhea and their acceptability. Of the mothers, 9.3% used the ORS, 75.4% used homemade fluids (HF), 6% used drugs and 9.3% used both ORS and HF. The acceptability of ORS among children was 57%, compared to 100% for homemade

Table 1: *General characteristics of the study group*

Characteristics	No (%)	Total No (%)
Residence		
Rural	79 (52.7)	150 (100)
Urban	71 (47.3)	
Socioeconomic status		
Low	71 (47.3)	
Middle	58 (38.7)	150 (100)
High	21 (14.0)	
Education		
Literate	101 (67.3)	150 (100)
Illiterate	49 (32.7)	

Table 2: *Types of early management of diarrhea and their acceptability*

Variable	No(%)	Total No
Types of early management		
ORS	14 (9.3)	150
Homemade fluids	113 (75.4)	
Drugs	9 (6)	
Combination (ORS+HF)	14 (9.3)	
Child's acceptability		
Homemade fluids		113
Accepted	113 (100)	
Unaccepted	0	
ORS		14
Accepted	8 (57)	
Unaccepted	6 (43)	
Drugs		9
Accepted	6 (66.7)	
Unaccepted	3 (33.3)	
Combination (ORS + HF)		14
Accepted	9 (64.3)	
Unaccepted	5 (35.7)	

fluids, 66.7% for drugs and 64.3% for a combination of ORS and HF.

Table 3 shows some homemade fluids commonly used in the state of Gezira; 42.5% used sorghum, 20.3% used rice water. Other homemade fluids including Gonglias "Adansonia digitata", Hilba juice "Fenugreek", and custard were used by 7.2% and 15% used a combination of ORS and homemade fluids.

Table 3: *Homemade fluids used by mothers/ families in the state of Gezira (N=113)*

Types of homemade fluids	No (%)
Sorghum (Nasha)	48 (42.5)
Rice water	23 (20.3)
Sugar salt solution	17 (15.5)
Other (Gongolais, hilba, custard)	8 (7.2)
Combination (Nasha + RW)	17 (15.0)

Table 4: *Comparison of homemade fluids with ORS effects*

Types of fluids	Stool output (%)			General condition (%)	
	Reduced	Increased	No effect	Improved	Not improved
Nasha	52.1	27.1	20.8	62.5	37.5
Rice water	60.8	30.4	8.8	65.2	34.8
Sugar salt solution	35.3	42.2	23.3	52.9	47.1
Other homemade fluid	37.5	35.2	25.0	62.5	37.5
Nasha + rice water	52.9	35.3	11.8	58.8	41.2
ORS	37.5	42.9	21.4	78.6	21.4
Homemade fluid	68.1	18.6	13.3	80.9	20.0

Table 5: *Chemical composition and some characteristics of different fluids*

Chemicals/ Characteristics	Sorghum solution (n=36)	Rice water (n=10)	Standard ORS	p-value
Carbohydrate (g/l)	80.37 ± 19.77SD	50.25 ± 12.67 SD	20.00 (glucose)	0.00004
Sodium (mmol/l)	37.37 ± 3.50 SD	51.74 ± 4.50 SD	90.00	<0.0001
Potassium (mmol/l)	11.71 ± 3.50 SD	13.66 ± 2.17 SD	20.00	0.102
Chloride (mmol/l)	18.24 ± 3.33 SD	34.75 ± 2.07 SD	80.00	<0.0001
Protein (g/l)	38.39 ± 22.63 SD	25.00 ± 6.36 SD	0.00	0.08
Fat (g/l)	6.53 ± 2.93 SD	3.5 ± 0.93 SD	0.00	0.026
Crude fiber (g/l)	6.49 ± 2.91 SD	4.10 ± 1.59 SD	0.00	0.017
Ash (g/l)	9.73 ± 2.53 SD	7.56 ± 1.81 SD	5.69	0.016
pH	4.33 ± 0.48 SD	6.56 ± 0.05 SD	7.00	0.0006
Specific gravity	1.04 ± 0.02 SD	1.01 ± 0.01 SD	-	0.016
Calculated energy (cal/l)	492 ± 98 SD	333 ± 76 SD	80.00	0.0002

Table 4 presents the comparison of the effects of homemade fluids and ORS, on the stool output and the general condition of the children. Homemade fluids, in general, reduced the stool output in 68.1%, increased it in 18.6%, and showed no effect in 13.3% of the children. HF improved the general condition in 80% of the children. In comparison, ORS reduced the stool output in 37.5%, increased it in 42.9%, and had no effect in 21.4% of the children. The general condition improved in 78.6% of the children who received the standard ORS.

The chemical combination and some characteristics of selected HF with that of ORS are presented in Table 5. The mean total soluble carbohydrate of sorghum-based solution was 80.74% ±19.76 g/l and was 50.25 ±12.67 g/l for rice water, whereas ORS contained 20g/l in the form of glucose. The mean sodium (Na^+) was 37.37 ±8.13 mmol/l, 51.74 ±4.50 mmol/l, and 90 mmol/l for nasha, rice water and ORS, respectively. The mean potassium level was 11.71 ±3.50 mmol/l, 13.66 ±2.17 mmol/l, and 20 mmol/l for nasha, rice water and ORS, respectively. The chloride levels for these solutions were 18.24 ±3.33 mmol/l, 34.75 ±2.07 mmol/l, and 80 mmol/l respectively.

The mean protein level was 38.39 ±22.63 g/l for nasha, and 25.00 ±6.36 g/l for rice water, while their mean fat was 6.53 ± 2.93 g/l and 3.51 ±0.93 g/l respectively. Crude fiber was 6.49 ±2.91 g/l and 4.10 ±1.59 g/l respectively. The mean ash level was 9.73 ±2.53 g/l in nasha, 7.56 ±1.81 g/l in rice water and 5.69 g/l in the standard ORS. The mean energy value of nasha was 492 ±98 cal/l and 333 ±76 cal/l in rice, whereas it was 80 cal/l in the standard ORS. The mean pH of nasha was 4.33 ±0.48, 6.56 ±0.05 in rice water and 7.00 in the standard ORS.

DISCUSSION

The majority of women in this study preferred homemade fluids to ORS. All the women (100%) accepted the homemade fluids as compared to 57% for ORS. This could be due to the greater palatability of HFs and that they are prepared from staple foods traditionally used in weaning. The homemade fluids reduced the stool output in 68.1% of the children compared to only 37.5% who used the ORS. This was the case in other communities where mothers' dissatisfaction with ORS was evident.[6] The effects of HFs on the stool output could be due to the starches (the polymeric forms of glucose) in these fluids which enhance water absorption and reduce the stool volume.[16,17] The low acceptability of the ORS and its ineffectiveness in reducing stool output results in persistent desire to use antidiarheal drugs and discontinue rehydration. This sometimes necessitates hospital admission for proper rehydration.[15]

The soluble carbohydrates, electrolyte contents and pH of sorghum-based solution and rice water which are comparable to that of ORS, were recommended as safe, efficient and reliable for rehydration during acute diarrhea.[7] The pH of sorghum-based solution is low as a result of cereal fermentation. It has been reported that it has some anti-microbial effects but is without acidotic ill effects during diarrhea.[18] The prevalence of diarrhea was also reduced among children who used lactic acid fermented cereal gruel in Tanzania.[19] The pH of rice water is close to that of standard ORS.

The addition of sucrose sugar to gruel, inhibits the build up of osmotic pressure, increases the salt and water absorption and reduces the stool volume.[16] Proteins in 'nasha' and rice water hydrolyzed to amino acids and di-peptides enhanced the absorption of sodium and water. The moisture contents of these fluids were similar to that of human and cow's milk.

Sodium chloride concentration in 'nasha' and rice water was low, both being around half that of ORS. This could be modified,

with the addition of salt to compensate for the sodium loss during diarrhea. Potassium concentration of the two fluids was more than half of the standard ORS. To simulate the levels in ORS, 52.63 mmol (1.21 g) of sodium and 61.76 mmol (2.2 g) of chloride should be added to sorghum-based gruel, and it is recommended that 3 – 3.5g of table salt be added to one liter of 'nasha'. Similarly, the addition of 2.3 – 2.6g of NaCl to one liter of rice water will adjust the concentration of both Na^+ and Cl^- to one similar to that of ORS.

CONCLUSION AND RECOMMENDATIONS

Apart from supplying the child with water, electrolyte and energy, homemade fluids also have the advantage of providing small amounts of other nutrients such as minerals and vitamins. Hence, the National Diarrhoea Control Programme has developed a strategy to promote the use of homemade fluids to prevent dehydration. The fluids in the present study have considerable amounts of electrolytes, are accepted by the children and their mothers, and are readily available and easily prepared. As such, they can be successfully used after the recommended adjustment, both for rehydrating children with some degree of dehydration after episodes of acute watery diarrhea, and also for the prevention of dehydration. These homemade fluids should be considered feasible alternatives to ORS where it is not readily available.

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