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Nutritional efficacy of Baobab (*Adansonia digitata*) Extract as a Substitute for ORS in the Management of Diarrhea in Children under Five in Sinnar State, Sudan

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Abstract

The study was conducted to evaluate the Nutritional Efficacy of Baobab (Adansonia digitata) Extract in the Management of Diarrhea in Children Under Five in Sinnar State, Sudan. The study sample included 60 children suffering from diarrhea in Singa Teaching Hospital in the period from April 2018 to April 2019. The demographic data was collected by interviewing (Questionnaire) children mothers. The data was analyzed by Statistical Package for Social Sciences (SPSS).

Sixty children with moderate diarrhea were given ORS as a control and Baobab (Adansonia digitata) solution in the Emergency Department (CED) over a period of 2–6 h, under supervision of a trained team to restore weight lost and balance Na^+, K^+ levels and thus remove and reduce signs of dehydration.

The result showed that the majority of the patients were of the ages 11 - 20 months including (60%) males and (40%) females. Most of the patients (70%) had sunken eyes, (65%) were unable of drinking and (66.6%) were sufferings from skin pinch goo's back.

The mean values of moisture, ash, protein, fat and fiber contents in Baobab powder were (2.03%), (3.48%), (2.33%), (0.72%) and (6.74%) respectively.

The mean values of tannins contents in Baobab powder were (0.30mg/100g), phenols (3.06 mg/100g) and phytic (0.20 mg/100g). The concentrations of Fe, Cu, Pb and Co content in Baobab powder were (8.38mg/100g), (0.38mg/100g), (0.003mg/100g) and (0.0140mg/100g) respectively.

The composition of the Baobab extract solution used was as follows; 27 g Baobab (Adansonia digitata) + 10g sugar + 1.5 NaCl completed to 1-liter water. Each child was given 75 ml/ 1kg wt. from this extract solution.

The results showed that children with moderate diarrhea who were given a solution of Baobab had improved by (97%) and were better than those given (ORS). Their weights and (Na^+) and (K^+) levels were restored. The taste of Baobab extract solution was accepted by the children more than ORS solution.

The study concluded that Baobab solution had proved successful for the children with moderate diarrhea in restoring the weight lost due to diarrhea, addressing the defects in the electrolytes and thus removing and reducing the signs of dehydration. Besides it is a local natural product, cheap and acceptable by the children.

Key words: Nutritional Efficacy, Baobab (Adansonia digitata) Solution, Diarrhea in Children under Five

INTRODUCTION

Diarrhea is one of the main causes of morbidity and mortality in children under the age of 5 years. In view of this problem, the World Health Organization has encouraged studies for treatment and prevention of diarrheal diseases (Agbon *et. al*., 2013).

Poor sanitary conditions in disaster-stricken areas result in higher risk for diarrheal illness invulnerable populations, especially children. This disease negatively impacts the nutritional status of affected children and causes significant morbidity and mortality.

Early diagnosis and treatment are thus essential to reduce the impact of diarrheal diseases on people affected by disasters. Early identification of cases allows the implementation of measures needed to prevent or lessen outbreaks that can occur in displaced populations in this context. The use of primary care management tools, such as the Integrated Management of Childhood Illness (IMCI) strategy is highly important. (WHO, 1988)

Dehydration resulting from acute diarrheal illness is one of the most significant causes of morbidity and mortality in populations displaced by disaster. In some cases, it accounts for more than 50% of the deaths during the initial stages of a humanitarian emergency. The use of Oral Rehydration Therapy (ORT) has markedly reduced the morbidity and mortality associated with dehydration caused by diarrheal illness regardless of the etiology.

In some communities, the reliance on indigenous medicinal plants often can be attributed to a lack of medical doctors and unaffordable prices of pharmaceutical products, as well as people's faith in the benefits of traditional medicine (Issa *et al.,* 2018; Khider, 2018).

In Sudan, the medicinal and Aromatic Plants Research Institute (MAPRI) of the National Centre for Research (NCR) is exerting efforts for collecting, conserving, studying and documenting indigenous medicinal and aromatic plants in Sudan. Traditional medicine together with use of medicinal plants become an important part of the cultural heritage of Sudan (Watt & Breyer-Brandwijk, 1962; Skerman, 1965; Elkhalifa, 2004; El badwi et. al., 2014; Abu Elgasim et al., 2016).

An investigation of anti plasmodial activity of selected Sudanese plants revealed that most plants from the family *Meliaceae* showed highly potent anti plasmodial activity (Ahmed *et al.,* 2010). The herb *Aristolochia bracteolate* (umglalagil) had been used to cure malaria in traditional medicine, however it had negative effect on kidneys (Khider, 2018). The roots of *Balanites aegyptiaca* contain steroidal sapogenins which have strong detergent properties that form very stable foam in water solutions. Whereas, the bulb contains sugars and saponins exhibiting anti-inflammatory and immune-boosting properties as well as antibacterial effects. (Eltohami,1997).

Justification

Malnourished children are increasing in number in Sinnar State, Sudan due to poverty in addition to the high illiteracy. Oral Rehydration Solution (ORS) taste is not acceptable or palatable to children and their mothers are reluctant to give ORS at home, since it usually needs Nasogastric tube to administer. Baobab (*Adansonia digitata*) fruits are traditionally consumed and readily accepted by the Sudanese.

Objective:

The main objective of this study was to investigate the nutritional efficacy of Baobab as a substitute for ORS and to determine the suitability of the extraction method to formulate an effective rehydration solution. Furthermore, to test and compare the prepared Baobab extract solution with the standard ORS regarding the acceptability and recovery patterns of the dehydrated children.

MATERIALS AND METHODS

Materials: ORS, Baobab (*Adansonia digitata*), Sugar, NaCl and Water.

Subjects and study Location: Hospitalized Children under five suffering from moderate Dehydration problem were selected randomly from Singa Teaching Hospital, Temporary Residence and Abu Ella centers, Singa, Sudan.

METHODOLOGY

Design: Patients were divided into two groups (60 each) subject to treatment by using the oral rehydration salt (ORS) as a control group and using Baobab solution as group two.

Flow Up: 36 males and 24 females in each group were under the care of a nurse and the researcher for the collection of blood samples before and after treatment to test Na^+ and K^+, levels, observing, resolving and decreasing dehydration.

Preparation of Baobab (*Adansonia digitata*) powder Extract: The powder of Baobab (*Adansonia digitata*) was collected from the

city of Singa and was prepared by separating the seeds from the powder by shaking.

Preparation of Baobab Solution: Aseptically the specific amount of Baobab (*Adansonia digitata*) powder was measured according to the concentration of sodium and potassium required. The quantity was soaked in a liter of sterile water for 10 minutes, blended for 30 seconds and filtered. Extraction and solutions were made as shown in Figure (1).

Baobab (Adansonia digitata) Prepared Solution Contents:

27 g of Baobab (*Adansonia digitata*) +10g sugar +1.5 NaCl completed to 1-liter water (Tables 2 a and b)

Analysis of Powder and Extract

The Moisture, Ash, Protein content and Crude fibre of (Baobab) samples were determined according to the modified method of AOAC (2000). The determination of heavy minerals from ash was done by using atomic absorption spectrophotometry. Determinations of sodium and potassium were done by flame photometer and the determinations of sugar were done by High Performance Liquid Chromatography (HPLC) (Ultimate 3000).

Exposure Time: 6 hours' Specific dosage was applied. A very vigilant and adequate control was implemented and the response was closely watched. The disappearance of rehydration symptoms (Lethargic, restless, Absence of tears, Sunken eyes, Dry mouth and tongue, thirsty, skin pinch goes back) were recorded (Table 1). Blood samples were taken and the electrolytes were examined after taking full dose of the specific solution using Electrolyte Equipment (Roche1980 Electrolytes Analyzer). Weight was monitored in 0 time, 2 hours and after 6 hours.

Figure 1: Preparation of Baobab (*Adansonia digitata*) solution

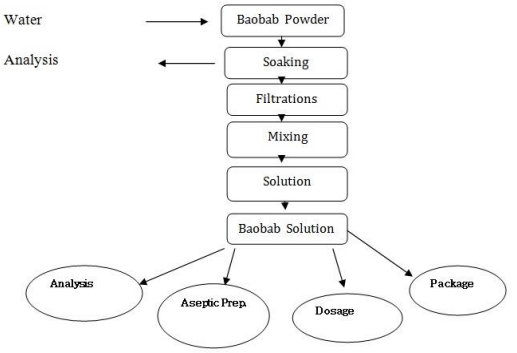

Table 1: Degree of Dehydration

Classification	General	Eye	Drinking	Skin
Sever of dehydration	Lethargic	Sunken	Unable to drink	V. Slow
Moderate dehydration	Irritable	Sunken	Eager	Slow
No dehydration	Alert	Normal	Normal	Normal

Table 2a: The Concentrations of Sodium, Potassium and Glucose in 20g/l Solutions

Solutions	K+ mg/l	Na+ mg/l	Glucose gm/l
ORS	162.350	171.429	13.5
Baobab	119.797	2.539	4.67

Table 2b: The Concentrations of Sodium and Glucose in the administered Baobab Solution

Solutions	Weight (gm/L)	Na	Glucose
Baobab	**27**	**1.68 gm/l**	**10 gm/l**

RESULTS AND DISCUSSION

Table (3) shows that the majority of the patients (65%) were of the ages 11-20 months. All the patients in the two groups (36 males and 24 females each) were suffering from Diarrhea.

Symptoms of the Disease

Table (4) shows the symptoms recorded at admission. All children were irritable and most of the patients (70%) had sunken eyes, (65%)

were unable of drinking water and (66.6%) of the patients were sufferings from skin pinch goo's back.

Table (3) Age and Sex distribution among the Patients

		Frequency	Percent%
Age	Less than 10 month	6	10
	11 to 20 month	39	65
	21 to 30 month	9	15
	Above than 30 month	6	10
	Total	60	*100*
Sex		Frequency	Percent%
	Male	36	60
	Female	24	40
	Total	60	*100*

Table (4) Symptoms at Hospital Admission

		Frequency	Percent
General	Diarrhea	60	100
	Total	60	100
Lethargic		Frequency	Percent
	Irritable	60	*100*
	Total	60	100
Sunken eyes		Frequency	Percent
	Yes	42	70
	No	18	30
	Total	60	*100*
Drinking water		Frequency	Percent
	Unable	39	65
	Eager	21	35
	Total	60	*100*
Skin pinch goo's back		**Frequency**	**Percent**
	Very Slow	40	66.6
	Slow	20	33.*4*
	Total	60	*100*

Analysis of Baobab Powder

Table (5) shows that the mean values of moisture content of Baobab powder were (2.03%), ash (3.48%), protein (2.33%) fat content (0.72%) and the mean value of fiber content was (6.74%).

Gurashi *et al*. (2016) and Satti, (2018) reported a relation between fruit pulp of Baobab and fruit shape, type and location in

Sudan. Their results showed that dry matter was (86.5±0.7), crude protein (10.44±0.15), fat content (1.70±0.14) and carbohydrate (62.58±0.17) with the lowest spheroid emarginated fruit shape.

Biochemical studies had shown that the Baobab fruit pulp contained 2.6% protein, 0.2% fat, 2.61% fructose, 2.9% glucose and 12.8% sucrose. Previous studies on the chemical composition of Baobab showed higher results in total sugars and similar protein and fat contents (Abdel Galil, 1996).

Abdel Galil (1996) showed that Baobab was a nutritious fruit containing the four groups of nutrients: protein 2.6%, fat 0.2%, fructose 2.6%, glucose 2.9%, and sucrose 12.81% respectively.

Minerals and vitamin C in Baobab Powder

The results in (Table 5) show that the mean value of Vitamin C in Baobab powder was (282.21mg/100g). The electrolyte and inorganic content of Baobab showed it to be a rich source of K (217.39 mg/100g), Ca (531.41mg/100g), Fe (8.38 mg/100g), P (48.39mg/100g), Na (6.33 mg/100g) and Mg (203.87 mg/100g) respectively.

The prepared Baobab solution contained 76.2 mg/ litre Vitamin C, 143.4 mg/ litre Ca, 58.7 mg/ litre K, 13.1 mg/ litre P, 2.3 mg/ litre Fe, 1.7 mg/ litre Na and 55.0 mg/ litre Mg respectively.

Satti, (2018) stated in his study that the electrolyte and inorganic contents of Baobab were rich in K (450 ppm), Ca (670 ppm), Fe (53 ppm), Mn (57 ppm), Se (10 ppm), and Zn (10 ppm). Unusually high contents of the trace elements Ti (865 ppm) and Cr (297 ppm) were observed

Anti-nutritional Content of Baobab Powder

The mean values of tannins, phenols and Phytate contents of Baobab powder were (0.30 mg/100g), (3.06 mg/100g) and (0.20 mg/100g) respectively. (Table 5).

The prepared Baobab solution contained 0.1 mg/ liter Tannin, 0.83 mg/ liter Phenol, 0.05mg/ liter Phytic, respectively. Based on these results the Baobab solution was formulated.

Table (5) Chemical Composition of Baobab

Baobab Powder (%)							
	Moisture	Ash	Protein	Fat	Fiber		
Powder Mg/100g	2.03± 0.05	3.48± 0.25	2.33± 0.13	0.72±0.11	6.74± 0.10		
Minerals and vitamin C of Baobab Powder and Solution							
	Vitamin C	Ca	K	P	Fe	Na	Mg
Powder mg/100g	282.2±0.14	531.0±7.3	217.4±1.02	48.4±0.45	8.4±0.2	6.3±0.16	203.8±6.5
27 gm/litre Solution	76.2	143.4	58.7	13.1	2.3	1.7	55.0
Anti-nutritional content of Baobab Powder and Solution							
	Tannins	Phenols	Phytate				
Powder mg/100g	0.30±0.04	3.06±1.18	0.20±0.03				
27 gm/litre Solution	0.08 mg/litre	0.83 mg/litre	0.05 mg/litre				

Heavy metals in Baobab Powder

The data revealed that the mean values of Fe, Cu, Pb and Co contents of Baobab powder were (8.38 mg/100g), (0.38mg/100g), (0.003mg/100g) and (0.0140mg/100g) respectively (Table 6).

The prepared Baobab solution (27 gm/litre) contained 2.3mg/ liter Fe, 0.1 mg/ liter Cu, 0. 8 µg / liter Pb, and 3.8 µg /liter Co respectively.

Baidoo et al., (2013) and Malhotra, (1998) found that the average concentrations of Aluminium were (27.74 µg/g), Barium (13.10 µg/g), Bromine (3.01 µg/g), Cobalt (0.08 µg/g), Copper (14.9 µg/g), Iron (26.05 µg/g), Iodine (0.27 µg/g), Manganese (7.05 µg/g), Sodium (52.06 µg/g), Vanadium (0.08 µg/g), and Zinc (0.79 µg/g) in the dried fruit pulp. They also stated that the maximum level for lead was 0.2 mg/kg.

The average concentrations of trace elements in the Baobab in the dried fruit pulp were; Al (11.50 µg/g), Ba (17.3 µg/g), Br (2.45 µg/g), Co (0.07 µg/g), Cu (28.6 µg/g), Fe ((<42 µg/g), I (<0.04 µg/g), Mn (17.7 µg/g), Na (23.53 µg/g), V (0.035 µg/g), and Zn (12.06 µg/g); and Al

(27.74 µg/g), Ba (13.10 µg/g), Br (3.01 µg/g), Co (0.08 µg/g), Cu (14.9 µg/g), Fe (26.05 µg/g), I (0.27µg/g), Mn (7.05 µg/g), Na (52.06µg/g), V (0.08 µg/g), and Zn (0.79 µg/g)

Table (6) Heavy metals in Baobab

Heavy Metals in Baobab				
	Fe	Cu	Pb	Co
Powder (mg/100g)	8.38±0.36	0.38± 0.140	0.003 ±0.004	0.0140± 0.014
27 gm/liter Solution	2.3 mg/l	0.1 mg/l	0.8 µg/l	3.8 µg/l

Effects on (Na^+), (K^+) levels and weight of the children before and after treatment

The analysis in Table (7) revealed that the mean values of concentrations of (Na^+) before and after taking Baobab solution were (131.96 ± 3.73 mmol/dl) and (133.63 ± 3.81 mmol/dl), while the concentration of (K^+) obtained before and after taking Baobab solution were (3.16 ± 0.42 mmol/dl) and (3.48 ± 0.42 mmol/dl) respectively. These results were significant at ($P \leq 0.05$).

Furthermore, the weights of children significantly increased ($P \leq 0.05$) after taking Baobab solution from (6.94±1.73 kg) to (7.15±1.75 kg) respectively.

Table (7) Effects on (Na^+), (K^+) levels and Weights of the Children before and after Treatment with Baobab Solution

Item	**Treatment**	**Mean ± SD**	**Std. Error Mean**	**P. value**	**Correlation**
Na^+ (mmol/dl)	Before	131.96± 3.73	0.68278	≤ 0.05	0.845
	After	133.63± 3.81	0.69569		
K^+ (mmol/dl)	After	3.16± 0.42	0.07766	≤ 0.05	0.831
	Before	3.48± 0.42	0.07820		
Weight Kg	Before	6.94 ± 1.73	0.31608	≤ 0.05	0.997
	After	7.15 ± 1.75	0.32025		

ORS solution

The data in Table (8) show that mean values of concentrations of (Na^+) before and after drinking ORS solution were (131.21 ±4.14 mmol/dl) and (133.02 ±4.13 mmol/dl), while the concentrations of (K^+) obtained were (3.12 ± 0.374 mmol/dl) and (3.46 ± 0.405 mmol/dl) respectively. The results indicated that the weights of children significantly increased from (6.78 ±1.452 kg) to (7.01 ±0.26465 kg). These results were significant ($p \leq 0.05$) for the (Na^+), (K^+) levels and weights.

Although the World Health Organization (WHO, 1988) has recommended the use of a high-osmolarity (90 mEq/L Na^+) mixture of glucose and 3 salts (20 g glucose, 3.5 g sodium chloride (NaCl), 2.5 g sodium bicarbonate [$NaHCO_3$], and 1.5 g potassium chloride (KCl), in 1 L water), our study demonstrated that in this part of western Africa, a lower Na^+ content can be used effectively because the *V. cholera* infection is uncommon and results in a lower loss of Na^+ in the stool than in patients infected with *V cholera*. We developed a rehydration strategy that provided a higher osmolarity solution at the beginning of rehydration, followed by a lower osmolarity solution as suggested by (Pignatelli and Musumeci, 2003).

Table (8) The effect on (Na^+), (K^+) levels and weights of the children before and after using ORS

Item	Treatment	Mean ± SD	Std. Error Mean	P. value	Correlation
Na^+ mmol/dl	After	131.21± 4.14	0.75722	≤ 0.05	0.874
	Before	133.02± 4.13	0.75326		
K^+ mmol/dl	After	3.12± 0.374	0.06833	≤ 0.05	0.924
	Before	3.46± 0.405	0.07407		
Weight Kg	After	6.78± 1.452	0.26521	≤ 0.05	0.997
	Before	7.01± 1.449	0.26465		

Although there were differences in the levels of (Na^+), (K^+) between Baobab and ORS treatment (Table 9), the Baobab (*Adansonia digitata*) solution was better than the ORS) in the acceptability of the children and mothers, its effectiveness in removing the symptoms of

dehydration and the fact that it is a cheap local product that could be used at home lessening hospital stays.

Numerous studies (Galil and Elhuda, (1996); Palombo, 2006) had validated the traditional use of antidiarrheal medicinal plants by investigating the biological activity of extracts of such plants, which have antispasmodic effects, delay intestinal transit, suppress gut motility, stimulate water adsorption or reduce electrolyte secretion. Our study proved that Baobab rehydration solution was effective, acceptable, local and cheap.

Table (9) Comparison between taking Baobab solution and ORS solution at day 7

Item	Baobab	ORS
Δ Na^+ mmol/dl	1.667	1.807
⊿ K^+ mmol/dl	0.315	0.346
Weight gain kg	0.212	0.220

CONCLUSION:

Baobab (*Adansonia digitata*) rehydration solution was acceptable as diarrhea management solution for both children and their mothers compared to ORS. Baobab helped in removing the symptoms of dehydration. Furthermore, Baobab (*Adansonia digitata*) is a nutritious cheap local product that could be used at home lessening hospital stays.

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