
# EVALUATION OF BAOBAB (Gonglase) SOLUTION FOR HOME MANAGEMENT OF DIARRHOEA IN SUDANESE CHILDREN

A THESIS SUBMITTED TO THE UNIVERSITY OF KHARTOUM
FOR THE DEGREE OF Ph. D. (AGRICULTURE)

By

NOUR ELHUDA ABDEL GALIL
M.Sc. BIOCHEMISTRY FACULTY OF
MEDICINE U. of K. (1985)
B. Sc. BIOCHEMISTRY FACULTY OF
AGRICULTURE U. of K. (1977)

SUPERVISOR: PROF. ABDALLA HAMID ELTINAY
B.Sc. (KHARTOUM), M.Sc., Ph.D.
(CALIFORNIA)

CO-SUPERVISOR PROF. ZEIN A. KARAR
FRCP (LOND) FRCP (EDIN)



JUNE 1996

We regret that some of the pages in this report may not be up to the proper legibility standards, even though the best possible copy was used for scanning

DEDICATION

IN THE NAME OF MY CHILDREN THE WORK IS

DEDICATED TO ALL SUDANESE CHILDREN

TABLE OF CONTENTS

ACKNOWLEDGMENTS

I wish to express my limitless gratitude to my supervisor Professor Abdalla Hamid El Tinay for his invaluable guidance throughout the course of this work. I would like to thank Professor Zien El Abdeen Abdel Rahim Karar for his generous help, patience during reviewing the manuscript, guidance and constructive comments within his capacity as a co-supervisor.

I have profited immensely of facilities offered by Dr. Tag El Asfia (Faculty of Vet. Sci., U of K). Dr. M. M. Bilal Elobied Research Station (ARC/West Sudan) and Dr. Osman Dawi (Faculty of Science U. of K.).

I am deeply grateful to Dr. M. O. El Obeid Central, Food Quality Control Laboratroy, Al-Ain Muncipality Dept., United Arab Emirates for assistance provided in some of the analytical work.

Dr. Sulaf El Din S. M. Tahi (Mowafag Charity Cooperation) is acknowledged for incentives given to mothers and children who kindly volunteered as human subjects in this study.

I am indebted to the Director FRC (Shambat), and the Director General ARC (Wad Medani) for offering the study release; and to the staff of the Biochemistry and Nutrition Section (FRC) and my colleagues Dr. M. El Amin El Hassan, Dr. Yahia Magzoub for their friendly gesture towards execution of the work.

I am also grateful to Mr. Ashraf Gaffar (British Council)

for furnishing vital information needed for the work.

I also wish to thank the staff of the Health and Nutrition at Ahmed Gasim Teaching Hospital, and the staff of Shabia and Khartoum Health Centers (Khartoum North).

Last but by no means least the encouragement and assistance offered by my family and husband during the course of this work are surely appreciated.

ABSTRACT

A randomized controlled study was carried out in Khartoum North during the year 1994 - 1995 at Ahmed Gassim Children Teaching Hospital, Khatmia, and Shabia Health Centers to evaluate acceptability, safety and efficacy of three formulated baobab home oral rehydration solutions in children with diarrhoeal diseases. One hundred and thirteen children 6 - 60 months of age were enrolled in the study with mild or no dehydration and without associated diseases.

Three baobab solutions were administered beside the control WHO/Oral Rehydration Solution (ORS). Thirty two were allocated to solution A (baobab pulp extract + home sugar), 35 patients to solution B (baobab pulp extract + domestic salt + sugar), 25 patients to solution C (baobab pulp extract + WHO/ORS) and 21 patients to the control solution (WHO/ORS).

The above mentioned solutions were administered for three successive days to the children with diarrhoea. A questionnaire was filled for each child including attitudes and practices of mother regarding diarrhoeal diseases, the socioeconomic status of the parents, the history of the patient health and past nutritional intake and intake during the present diarrhoea. The clinical data after the administration of the rehydration solutions were studied.

The study showed that the baobab oral rehydration solutions were more acceptable, effective, and safer than the

control WHO/ORS.

The three solutions A, B and C were good as therapeutic solutions and exceeded that of the WHO/ORS.

Clinical data demonstrated that after 24 hours of management of the diarrhoeal diseases with baobab solutions, the recovery rate was 60% for solution A group, 20% for solution B group and 28% for solution C whereas the recovery rate for solution D was 5%. By the second 24 hours of management the cumulative recovery rate was 100% in case of solution A, 77% in solution B, 84% in solution C whereas with the control D solution was only 24%.

None was considered a treatment failure or developed dehydration and all the patients were satisfactorily treated with marked effect on children with diarrhoea, specially bloody diarrhoea. The molar concentration of potassium in the baobab solution was found to be 21 mmol/litre very close to the molar concentration of potassium in The WHO/ORS (20 mmol/litre). Solution A was hypo osmolar (170 mosm/litre), solution B was normal (282.5 mosm/l) and solution C was hyper osmolar (337.5 mosm/l).

Biochemical results demonstrated that baobab is a nutritious solution, containing the four groups of nutrients. Energy-yielding nutrients, protein 2.6%, fat 0.2%, fructose 2.6%, glucose 2.9%, sucrose 12.8%. The electrolyte and inorganic content of baobab showed it to be a rich source of

K (450 ppm), Ca (670 ppm), Fe (53 ppm), Mn (67 ppm), Se (10 ppm), Zn (10 ppm). Unusual high content of the trace elements Ti (865 ppm) and Cr (297 ppm) were observed. The vitamins studied were ascorbic acid (335 mg/100g), free nicotinic acid (50 mg/100g) and Vitamin $B_6$ (10 mg/100g). The fibre content of the baobab was pectin 56% and crude fibre 5.7%.

## LIST OF FIGURES

## LIST OF TABLES

# CHAPTER I

## 1.1 Introduction:

Diarrhoea is the second commonest cause of death in childhood the world over and the most frequent in infancy in countries of poor hygiene. Although in developed countries this disease is seldom fatal, it is the second most common reason for children hospitalization[1]. The European children experience in their first 3 years of life, approximately one episode/year[2]. In the developing world each child experiences on the average 5 episodes/year. In some areas the incidence is much higher than estimated, 4-5 millions diarrhoea - associated death occur annually in the world[3]. In central Africa the results of a survey in children of less than 5 years old revealed that diarrhoea was most common with 3.9 episodes/child annually[4].

A study in 1984 of the impact of diarrhoeal disease on childhood deaths in the Republic of South Africa revealed that 27.7% of all registered death of children under 5 years of age were due to diarrhoea[5]. In Lahore, Pakistan, infantile diarrhoeal disease of those less than 2 years, showed each child exhibited an average of 3.6 episodes/year and 4.3 episodes/year in the villages[6].

In Sudan a household survey conducted in October 1992 in Khartoum province covering 5750 households, showed that 11.2% of the children had diarrhoea in the 24 hours preceeding the

interview, each child experienced 6.2 episodes of diarrhoea per year[7]. According to the Sudan Department of Health Survey (Sudan DHS, 1991) 18% of children less than 5 years had diarrhoea once during the 24 hours preceding the survey[8]. The health profile of Central Sudan (January, 1994), showed that the prevalence of diarrhoea in those less than 5 years old was 41.5% in the Blue Nile, 43% in Gezira and 36.8% in White Nile provinces[9]. Report of 1994 (January, October) showed that the diarrhoeal disease accounted for 11.56% of all outpatient visits to Ahmed Gasim Children Teaching Hospital which is the referral centre for acute condition of diarrhoea from Khartoum North (the population is about 0.5 million according to the last census 1993) and neighbouring areas. The mild cases of diarrhoea are referred to health centres. During the year of the study starting from January till October 1994 the diarrhoeal diseases of all children outpatients visits to Ahmed Gasim Children's Teaching Hospital were shown in the following table.

The peak of the incidence of diarrhoeal diseases was during July and August. Reports of 1990 showed that diarrhoeal diseases accounted for 22.35% of all outpatients visits to Children Emergency Hospital Khartoum and 25.21% of all hospitals admission.

In Sudan, where diarrhoea is a major cause of death, ORS use rate is low (13.2%)[10]. A survey of knowledge, attitudes and

Percentage of children with diarrhoea: outpatient clinic in Ahmed Gasim Children Teaching Hospital.

| 1994 | Outpatient frequency | Diarrhoeal disease frequency (%) |
|---|---|---|
| January | 5968 | 413 (8) |
| February | 6533 | 702 (11) |
| March | 6062 | 513 (9) |
| April | 7297 | 783 (11) |
| May | 6343 | 452 (8) |
| June | 6018 | 560 (9) |
| July | 5740 | 1112 (19) |
| August | 9842 | 1062 (19) |
| September | 4581 | 785 (18) |
| October | 5067 | 408 (14) |

practices of mothers in the rural communities of two villages in Sudan, regarding diarrhoeal diseases revealed that, although awareness about ORS was high only 25% could prepare and use it correctly[11]. In the same study ORS use rate was very low 2.1 - 4.3%. A survey conducted in El Obied (1987) showed that the ORS use rate was 24%[12], while a household survey conducted in Khartoum showed an even lower use rate[13].

The oral rehydration therapy remains under utilized. Household surveys in 33 developing countries have shown use rates of 20.8%, although 53% of households know about ORS and its correct preparation[10]. The main reasons for this low rates are mother perception of ORS as a 'medicine' that does not stop diarrhoea, with poor acceptability, availability and the cost[14,15].

The standard packaged glucose-based oral rehydration solution provides optimal rehydration of acute diarrhoea from any cause, but it does not reduce volume, frequency or duration of diarrhoea[16]. In Sudan rice water and a thin pap made from sorghum are the commonest fluids offered in the home to the children with diarrhoea[17]. A survey conducted in rural communities of two villages in Sudan revealed that home made fluids including rice water, custard, pap and tabaldi juice were used by 45% of the mothers[11].

1.2 Rationale of The Study:

The problems of availability of ORS at home level, safety

of preparation and acceptability even at places where ORS is available and utilized remains unresolved. Effects of drugs incidence of multiple antibiotic resistance in organism isolated, the association between persistent diarrhoea and malnutrition and the strong belief in tradition and religion raised the need for scientific evaluation of traditional medicines used for management of diarrhoea and can be used on the onset of diarrhoea. These should be available at the home level, and culturally acceptable. In Europe for example, the Netherlands, usually fruit juice and lemonade are usually given for management of diarrhoea. ORS is relatively of little use.

This study will address a popular indigenous fruit, baobab (Adansonia digitata) known locally as Gongolase. It is commonly chewed, sucked or made into a drink. Baobab solution have been used by the Sudanese for management of diarrhoea and dysentery. However, no study was carried out to evaluate it as a remedy for diarrhoeal diseases and compare it with the standard formulation (WHO/ORS).

1.3 The objectives of this study were:

1- To evaluate the potential value of baobab biochemically and to formulate and standardize different rehydration solutions from it and compare them to the standard WHO rehydration salts.

2- To evaluate the relative efficacy of these solutions

clinically as home management of mild diarrhoea and in improving the clinical state of hydration and prevention of dehydration.

3- To assess acceptability of these solutions by the children with diarrhoea and their mothers, and compare it with the standard formulation.

## CHAPTER II

## LITERATURE REVIEW

### 2.1 What is diarrhoea?

Diarrhoea in a clinical sense, is an increase in frequency or increased fluidity of bowel movement in a given individual. In pathophysiologic terms, diarrhoea results from the passage of stools containing excess water i.e. from malabsorption or secretion of water[18]. Diarrhoea can be defined as three or more loose or watery stools in 24 hours. Frequent passing of normal stool is not diarrhoea i.e. babies who are exclusively breast-fed often have stools that are soft. Diarrhoea is most common in children especially those 6-24 months of age, and is also common in babies under 6 months who are drinking cow's milk or infant feeding formulas.

Diarrhoea is classified as either acute diarrhoea, dysentery or persistent diarrhoea based on its duration and on the presence or absence of blood in the stools. An episode of diarrhoea less than two weeks is acute diarrhoea and if it lasts two weeks or longer it is persistent diarrhoea[19]. Symptoms are produced by one or more of the following mechanisms:

A. Production of enterotoxins

B. Increased synthesis of prostaglandins

C. Impaired reabsorption of fluids and electrolytes

In acute invasive diarrhoea, the pathogen penetrates the

epithelial cells of the intestinal mucosa. The invasive process often results in dysentery. Dysentery is characterized by watery stools containing blood and mucus., accompanied by cramps, rectal burning, fever and sometimes toxicity[20].

A comparison of children deaths due to diarrhoea in Brazil, Senegal, Bangladesh and India revealed that persistent diarrhoea accounted for over 60% of infant diarrhoeal deaths in Brazil, 47% in India, 36% in Senegal and 26% in Bangladesh. Over one half of infant diarrhoeal deaths were due to acute diarrhoea among 1-4 years old dying from diarrhoea[19].

There is a significant relationship between diarrhoea and malnutrition. Malnutrition predisposes children to a greater incidence and duration of diarrhoea as well as a greater incidence of persistent diarrhoea which is now emerging as a major cause of childhood mortality in tropical developing areas[22].

Dehydration could be mild when body fluid loss is less than 5% of the body weight, moderate when the loss is 5-9% of body weight and severe when the loss is more than 10% of body weight[23].

The assessment of the patient for dehydration is shown in the following table[19]:

A. no sign for dehydration

B. some dehydration

C. severe dehydration

Parameters for assessment of a child for dehydration.

| | A | B | C |
|---|---|---|---|
| Look at condition | Well, alert | *restless, irritable | *Lethargi unconcious, floppy* |
| Eyes | Normal | Sunken | Sunken and dry |
| Tears | present | Absent | Absent |
| Mouth and tounge | Moist | Dry | Very dry |
| Thirst | Drink normally, not thirsty | *Thirsty, drinks eagerly* | *Drinks poorly or not able to drink* |
| Feel skin pinch | Goes back quickly | Goes back slowly | *Goes back very slowly* |
| Decide | The patient has no sign of dehydration | If the patient has two or more signs including at least one *sign** there is some dehydration | If the patient has two or more signs including at least one *sign* there is severe dehydration |

2.2 Mothers Perception about Childhood Diarrhoea:

In rural Mexico mothers assess the severity of diarrhoea by the increase in the usual number of stools passed per day, the colour, smell and liquid content of the stool, and by how much the episode of diarrhoea interfered with the children daily activities. The worsening or improvement of the children with diarrhoea is assessed by symptoms related to the child's usual well-being. The more important signs they recognize are focused on the child's eyes[24]. In Guatemala nearly all the studied groups relate childhood diarrhoea to the humoral theory of disease including the concept of evil eye. In the village they relate diarrhoea to a set of processes which could be either "hot" or "cold", stool colour being the primary concept used in household-level diagnosis[25].

In Sudan mothers with children less than 5 years of age were interviewed in two villages south west of Omdurman city (1988). Sixty seven percent of literate mothers believed that diarrhoea was caused by contamination compared to 42% of the illiterate ones. More than 90% of mothers attributed diarrhoea to teeth eruption, less than 12% to bottle feeding and fermented foods. More than 60% of mothers attributed diarrhoea to drinking of salty water or hot water. More than 60% of mothers attributed diarrhoea to suckling breast milk of pregnant mothers. Less than 40% mentioned that the consequence of diarrhoea was thirst and dry mouth. Less than 3% mentioned

depressed anterior fontanelle[11].

2.3 Child Care Practices and Hygiene:

Food for children must be well cooked. Freshly prepared foods must be given to children to minimize the chance of contamination. If previously prepared foods must be offered, they must be reheated.

Safe water and latrine must be used with good personnel and domestic hygiene measures. A survey was done in three villages of district Alwar (India) covering 875 children less than 5 years old. It was estimated that only about 3.7% of mothers washed their hands before preparing meals, while only 1.6% washed their hands after toilet[26].

In Lahore (Pakistan) the maximum incidence of diarrhoeal episodes occurred in children between 9-10 months of age. A result of a study in 1476 infants showed the peak of incidence of persistent diarrhoea occurred in June and July[6]. Another study in the same country taking into consideration child care practices and hygiene measures, in the same infants born between September 1984 and March 1987, estimated that one third of the families from the village and periurban slum fed children foods 12 hours after being cooked. The surroundings of the children were dirty with large numbers of flies present throughout the year[28].

In Sudan (1994), the health diseases profile in Central State which is characterized by the presence of huge

irrigation schemes have negative health impact upon the population. This resulted in the common prevalent diseases, schistosomiases and diarrhoeal diseases[9].

2.4 Diarrhoea Treatment:

The most important treatment of diarrhoea is prevention of dehydration from occurring by home treatment of diarrhoea, which is the topic of our study. Rehydration and maintenance of proper fluid and electrolyte balance are the most important aspects of treatment, while intravenous rehydration is the best form of treatment for children who are in shock or unable to drink[28].

2.5 Dispensing Habits of Pharmacists in Treating Diarrhoea:

It is claimed that antidiarrhoeal drug can not be recommended for children less than 4 years of age[29]. In Guatemala, the concept of the drug store sales force on the management of acute diarrhoea in children was studied by means of a direct interview of 427 employees of 427 drug stores. The study revealed that 33% of the employees have grammar education or less i.e. young adults without training in medicine or drug therapy. Eighty two percent stated that antibiotics are indicated always or almost always, 69.8% prescribed caolin and pectin as antidiarrhoeal alone or in combination with antibiotics or sulfanamides, 33% prescribed antibiotic, 23.5% prescribed oral rehydration, but only 8.7% of drugstores had oral rehydration salts recommended by

WHO/UNICEF[30].

In Tlaxcala (Mexico) a study focused on children 72 hours to 5 years old who died of acute diarrhoea, concluded that 65% of treatments for acute diarrhoea were considered erroneous, either due to the lack of oral rehydration therapy when it was needed or to the use of an antibiotic which was not justified. Also late referral to a hospital was considered as having direct influence on the death of 50% of the patients. The families were too late in demanding medical care or no care was demanded in 6.1% of cases of acute diarrhoea[31].

In Penjaringan, an urban district of Jakarta, the practices of physicians who treat acute childhood diarrhoea showed that antibiotics were prescribed for children in 94% of observed cases, and antispasmodic drugs were also commonly prescribed[32].

Management of infantile diarrhoea by physicians in outpatient services in Peru was studied. The study showed that antibiotics were prescribed for 58% of the infants, 46% were not given any ORT. The ORS was recommended to 18% only. The results revealed a sizable discrepancy between theory and practice in the medical management of childhood diarrhoea[33]. The dispencing habits of 60 Johannesburg pharmacists in treating acute infantile diarrhoea revealed that 16% had never heard of oral rehydration therapy, while 39% treated this condition with antidiarrhoeal drugs[34]. In Sudan the dispensing

practices of Khartoum and Khartoum North pharmacies with respect to the management of infantile diarrhoea (their mothers presented pharmacists with a brief description of an infant with acute diarrhoea) were studied. Out of 63 pharmacies only 5% recommended oral rehydration salt alone. 6% recommended oral rehydration salts plus either antimicrobial agent or a physician visit. 62% recommended antimicrobial therapy alone, 14% recommended a physician visit alone and 11% had no available treatment. The antimicrobial cost is four times more than two packets of ORS on average[35].

All these findings on the dispensing habits of pharmacists in treating diarrhoea are perturbing, because acute diarrhoeal disease is the biggest cause of mortality of children and oral rehydration therapy is recognized as an effective means of prevention of deaths. ORT is one of the essential components of child survival technologies with a global effort to reduce deaths from dehydration and diarrhoea associated malnutrition. Patients with dysentery need antimicrobial therapy apart from ORT. Clinical experience has shown that with ORT and appropriate dietary therapy, most patients with persistent diarrhoea can be managed effectively. Unfortunately, injudicious use of intravenous fluid and irrational prescription of antidiarrhoeal and antibiotic agents is quite common even with pediatricians[36].

2.6 Oral Rehydration Solutions:

Over the past twenty years there have been many important advances in knowledge about the diarrhoeal diseases of children. Therapy is primarily concerned with the prevention or correction of dehydration and maintenance of nutrition. The scientific development of oral rehydration solution for treatment of acute diarrhoea was considered from physiological concepts. It is the major single therapeutic advance in the field of diarrhoeal diseases in recent years. The World Health Organization (WHO) has adopted ORT and strongly promoted its application for treatment of diarrhoeal diseases particularly in developing countries. This has resulted in a drop of diarrhoeal diseases mortality. The application of ORT was described in an editorial in the Lancet as "potentially the most important medical advance of this century". ORT is based on the observation that intestinal sodium transport is enhanced by glucose transport in the small intestine. The sodium coupled mechanism for glucose and water transport remains intact in the enterotoxigenic diarrhoea, despite the net secretory effects of bacterial enterotoxins on the small intestinal epithelium. This process provides the way to replace water and electrolyte lost in the stool[37,38,39,40].

A solution of salts and glucose in water as an orally administered treatment for diarrhoea was recommended as early as 1949[41].

Table (A):

Composition by weight of oral rehydration salts ORS. (quantities shown are for preparation of one litre of ORS solution).

| Ingredient | g |
|---|---|
| Sodium chloride | 3.5 |
| Trisodium citrate, dihydrate | 2.9 |
| or | |
| Sodium hydrogen carbonate (sodium bicarbonate) | 2.5 |
| Potassium chloride | 1.5 |
| *Glucose anhydrous | 20 |

* Or glucose monohydrate 22.0g
Or sucrose 40.0g

Table (B) Molar concentration of components of ORS solution

| Component | mmol/litre of water | |
|---|---|---|
| | Citrate containing solution | Bicarbonate containing solution |
| Sodium | 90 | 90 |
| Potassium | 20 | 20 |
| Chloride | 80 | 80 |
| Citrate | 10 | - |
| Bicarbonate | - | 36 |
| Glucose | 111 | 111 |

The composition of the ORS solution recommended by WHO and UNICEF is shown in Table (A) and its molar concentration of components in Table (B)[42]. ORS is generally provided pre-packaged in a dry form to be reconstituted when required.

Although the importance of ORT for acute diarrhoea is unquestioned, controversy remains about the preparation and formulation of ORS. There is disagreement about whether ORS should be home made or commercially prepared, the optimal constituents of sodium, what base should be present if any, and whether nutrients can be substituted entirely or in part for glucose[43]. Besides the high sodium glucose electrolyte solution based on the WHO/UNICEF recommendations, many diverse formulations of ORS have withstood the trial of prolonged clinical use. Their main difference concerns the concentration of sodium, the choice of the glycidic component, the use of bicarbonate as buffer or its substitution with acetate or citrate[44].

Several studies evaluated the efficacy of ORS with different sodium concentrations in relation to the standard concentration (90 mmol/litre). The sodium levels studied were 26, 35, 50, 60 and 90 mmol/litre. All levels showed that no adverse drug reaction occurred, none was considered treatment failure[45,46,47,48,49,50]. Also a study confirmed the efficacy of the standard ORS for the treatment of all cases of acute diarrhoea, including severely malnourished children[51]. Several

other studies were carried out for justification of the composition of WHO formula ORS[52] and its efficacy in treating acute diarrhoea[53], reducing diarrhoeal mortality[54,55,56,57,58,2] and antibiotic prescription for diarrhoeal children[58,59,60]. The studies also showed that the use of ORS resulted in cost savings attributable to diarrhoeal diseases[57,58,62] including the use of IV rehydration solution which has decreased considerably[60,61,62,57]. The worldwide experience during the last 20 years showed that no one would die (adult or infant) of diarrhoea if oral rehydration solutions were readily available and someone with knowledge in their use[63]. Other standard oral rehydration solutions include the British Pharmacopeia recommended ORS (UK - ORS): sodium 35 mmol/litre, glucose 200 mmol/litre, osmolality 310. Part of the problem in developing ORSs has been the lack of adequate test system for the assessment of new formulation before clinical trials[64].

Since the development of ORS for the treatment of diarrhoeal disease depends on knowledge of the disease process itself and the factors that determine movement of water and electrolyte across the gut, the fate of orally ingested solutions depends on:

1- The process of gastric emptying

2- The rates of absorption and secretion in the intestine.

There is no technique to investigate these two processes

together. The promising new technique to investigate these two processes (gastric emptying and intestinal transport) involves estimation of accumulation in the circulation of isotopic traces for water added to ingested solutions; thus the efficacy of new ORS must however be assessed in clinical trials of patients[65].

2.7 Rapid Intravenous Rehydration in the Treatment of Acute Infantile Diarrhoea:

The use of intravenous rehydration is necessary in severely dehydrated patients or when oral rehydration fails, vomiting and anorexia prevails. The principles of parenteral rehydration did not change during the last 20 years. Initially a rapid infusion of isotonic Ringer's Lactate solution, followed by half isotonic Ringer's glucose solution. The purpose is to give the patient a large quantity of fluid quickly to replace fluid loss in severely dehydrated patients. The aim is to prevent a circulatory collapse, to replace the deficit and maintain the requirement until oral feeding is restarted[66]. In developed countries, textbook produced recommended slow administration of fluids to correct dehydration in 12 - 24 hours. In developing countries due to the great number of severely dehydrated patients, this approach is not useful and a much shorter time (2 -3) hours is recommended with early refeeding[67]. In the United States the assessment and management of an infant with diarrhoeal

dehydration with rational plan for parental fluid therapy is based on physiologic consideration, the type of fluid to be infused depends on knowledge of the serum sodium.

The Control of Diarrhoeal Diseases (CDD) Programm in Sudan guidelines for management of severe dehydration, advocates that IV therapy must begin quickly in the amount specified. As soon as the patient is able to drink, some ORS should be given even while IV therapy is being given, and early resumption of feeding is recommended. In Mexico a result of a study in moderately-dehydrated infants with diarrhoea 11 days - 19 months in age who failed to respond to ORT showed that IV infusion rehydrated the patients successfully in 5.1±1.6 hours, and all the patients tolerated refeeding immediately after completion of IV infusion[69]. Sperotto developed an approach to IV rehydration during the last 20 years that permits rehydration of the severely ill patient in a much shorter time (2 - 3 hours) and permits an early refeeding[69]. In the United States it was found that very few pediatricians and family practitioners follow all aspects of The American Academy of Pediatrics. Its policy on the treatment of infants with acute diarrhoea complicated by mild to moderate dehydration was published in 1985. However, fewer than 50% of physicians started solids within 24 hours as suggested by AAP guidelines[70].

2.8 ORT - Therapy:

Oral rehydration solution was also used for treatment of an infant with congenital sodium diarrhoea[71], and for management of malnourished children with acute diarrhoea and sugar intolerance. The formula in this case was based on fermented milk together with oral rehydration[72].

The quantity of home-made ORS was studied in seven health sites in Africa, Asia and Latin America. The results showed that ORS was given in smaller volumes and for shorter periods of time than recommended[73]. A study recommended the use of commercially available ORS rather than home-made ORS solutions, to avoid the use of antidiarrhoeal and antibiotic agents, and to reintroduce milk formula or solid food early. Lastly instructions given to parents in measures to minimize transmission of infectious agents[28].

Recent work on the prevention of diarrhoea among children living in developing countries, where diarrhoeal disease is still a major cause of morbidity and mortality, include the following strategies[74]:-

- Promotion of breast feeding.
- Dietary supplementation with vitamins and minerals specifically vitamin A, zinc and iron.
- Hygienic preparation of weaning foods.
- To promote the use of fermented foods.

As acute diarrhoea gives rise to loss of water and

electrolyte, ORS contains glucose, Na, K, Cl and bicarbonate, in various concentrations. Studies have shown that the standard packaged glucose - based oral rehydration solution provides optimal rehydration from any cause, but does not reduce volume, frequency or duration of diarrhoea. A new ORS formulation has been developed in which glucose is replaced by 50 - 60g cereal staples[75]. When glucose is replaced by rice starch or when amino acids are added, then we have a "super solution". Nutrient intake provide more calories and increase absorption of Na without an osmotic overload. The result is increased net absorption of glucose, sodium and water. Glucose polymer from rice or other starches in ORS may be effective, inexpensive, easily used and safe treatment for acute diarrhoea.

A study in rural Bangladesh involving 2000 children 1 -4 years in age, suffering from acute diarrhoea, demonstrated the superior efficacy of rice ORS compared with glucose ORS or no ORS. The study suggested that staple - based or food - based ORS is the optimal treatment of diarrhoea. The cumulative recovery rate in day 3 of treatment was 66% in case of rice - based ORS, whereas with standard glucose it was 24% and was 11% with no ORS[75].

2.9 Pathophysiology of Potassium Absorption and Secretion by Human Intestine:

People normally absorb about 90% of K intake. The vast

majority of intestinal K absorption occurs in the small intestine. The contribution of the normal colon to net K absorption is trivial. Potassium absorption or secretion is by passive mechanism. The rectum and perhaps the sigmoid colon have the capacity to actively secrete K, but the quantitative and physiological significance of this active secretion is uncertain. Hyper aldosteronism increases fecal excretion by about 3 meq/day in people with otherwise normal intestinal tracts. The absorptive mechanisms of K are not affected by diarrhoea, but fecal K losses are increased in diarrhoeal diseases by unabsorbed anions (which obligate K), by electrochemical gradients secondary to active Cl secretion and probably by secondary hyperaldosteronism. In diarrhoea total body K can be reduced by two mechanisms:

1- Loss of muscle mass due to malnutrition.

2- Reduced net absorption of K which is the mechanism responsible to hypokalemia.

Available data suggest that dietary K intake, renal K excretion and fecal K determine whether or not a patient develops hypokalemia[76].

Optimum concentration of ORS ingredients has been carefully determined. Potassium is added for the treatment of dehydrated children in whom potassium losses in diarrhoea are relatively high. The citrate or bicarbonate is needed for the treatment of acidosis which occurs frequently with

dehydration. Glucose is included in the solution principally to help the absorption of sodium[77] which is needed for deficit replacement and maintenance needs of individual with either cholera or non-cholera diarrhoea[78]. Excess sodium from ingestion of ORS in quantities larger than needed is excreted by the kidney as circulation is restored and water is made available[79].

A study from the Netherlands discussed the future prospects for ORS based on food in Western developed countries[80]. It was concluded that there were extremely interesting developments with regard to new forms of ORS especially those based on food studies. It was suggested to evaluate food-based ORS in reducing the duration and severity of episodes of diarrhoea i.e. the treatment of diarrhoea accompanied by dehydration would be more simplified with an outpatient based ORS that could eliminate or at least reduce the unnecessary prescription of antidiarrhoeal drug[80].

2.10 Food - Based ORS:

Several food-based and cereal-based ORS solutions have been explored. Two ingredients probably explain the superiority of food-based solutions: The protein and starch. Even during diarrhoea, the starch - digesting enzyme amylase is present in large amounts in the upper intestine, so starch is hydrolyzed into glucose gradually, thereby providing the carrier glucose where it is needed most and without any of the

osmotic penalty which results when the quantity of glucose is increased in ORS[81]. The protein upon hydrolysis releases amino acids, hence more carrier molecules.

The second factor that explains the superiority of food-based solutions is the osmotic activity which is mostly lower than that of blood or other tissue causing water to be absorbed rapidly. This does not occur with glucose - ORS because its osmolality already exceeds that of blood. The normal range for serum osmolality is 285 - 295 mosm/kg[82].

2.11 Cereal - Based ORS:

Rice water has been traditionally used for treatment of diarrhoea for centuries in most Asian, Latin America and African countries. Several studies considered the evaluation of its efficacy in the treatment of diarrhoeal diseases. A study in Mexico[83] proposed the use of rice powder with only sugar, no sodium or other electrolyte, as a first line of management of diarrhoeal disease at home level, when oral rehydration salts are not available to prevent dehydration. Its use should be closely linked with rapid reintroduction of oral feeding[83]. Another study was carried out to evaluate the efficacy of cereal-based solutions, made either of maize, millet, sorghum or rice to standard ORS in the treatment of acute diarrhoea with moderate to severe dehydration after initial rehydration was achieved. The result showed that cereal-based solutions were as effective as the standard ORS[84].

A study in Mexico evaluated the efficacy and safety of two rice-based oral rehydration solution with and without added electrolyte in children with acute diarrhoeal dehydration and high stool output. The result demonstrated the efficacy of rice-based oral rehydration solution without added electrolyte over that with added electrolyte[86].

Another study[85] supports the continued recommendation of glucose-based ORS for treatment of dehydrated children with acute diarrhoea. The result of treatment of 460 boys aged 3 - 18 months showed that glucose - based ORS solution was more effective than rice-based ORS when a weaning food consisting of rice and mixed vegetables was given until the diarrhoea stopped. The study emphasized the importance of resuming feeding as soon as dehydration has been corrected[85].

A randomized controlled study was carried out at the Children Emergency Hospital, Khartoum, Sudan (1990) to evaluate acceptability, safety, and efficacy of cereal (rice + sorghum)-based ORS, relative to that of the standard WHO-ORS. The study revealed that cereal-based ORS was found acceptable by children and their mothers. It shortened the duration of diarrhoea, reduced the mean frequency of vomiting and the mean total ORS intake. It also reduced the mean number of diarrhoeal motions and stool output/kg body weight in the first and second 24 hours and during the total duration of diarrhoea compared to the standard solution. These effects

were more marked with the sorghum-based ORS[87].

A study in the International Centre for Diarrhoeal Disease Research, Dhaka, Bangladesh involving 93 boys less than 5 years of age who had diarrhoea due to Vibrio cholera demonstrated the role of ORS in turning off the diarrhoea. The treatment with standard ORS and normal food or rice-based ORS after initial 24 hours rehydration period with ORS, showed that the efficacy of glucose ORS was equal to that of rice ORS. The study suggested that food intake or standard ORS could not impact some of the superiority of rice-based ORS with regard to reduction of stool volume[88]. In an adult with cholera a study showed that food did not potentiate the efficacy of glucose-based or rice-based ORS; rice-based ORS compared with glucose ORS reduced purging in adult cholera patients[89]. Clinical trials on children and adults with high output diarrhoea showed that the use of cereal-based ORS produced significant reduction in stool volume. In children with non-cholera diarrhoea, cereal-based ORS was as effective as glucose-based ORS.

The addition of glycine to glucose-based ORS or rice-based ORS did not reduce stool volume or duration of diarrhoea, while analine reduced stool output and ORS requirement. The results suggested that more research is needed to determine the optimal mixture of starch, amino acids, oligopeptides and proteins that would utilize the

absorption active transport system[90].

Another study in 200 hospitalized Egyptian infants aged 3 - 18 months suffering from acute diarrhoea, concluded that infants who were given rice-ORS reduced total output by 35% compared with the control group. Feeding of boiled rice-based formula immediately after rehydration was as efficacious as treatment with rice - ORS alone for 24 hours, followed by feeding with a soy-based, lactose free formula[91].

Several other studies demonstrated the efficacy of rice-based ORS; inexpensive[92], easily used and safe treatment for acute diarrhoea[93,94]: Other studies suggested the role of cereal-based oral rehydration therapy in children suffering from persistent diarrhoea[95], and acute diarrhoea in malnourished children 6 months - 3 years old[96]. Rehydration with carrot rice-based ORS was found to be more efficient than standard ORS in the treatment of children with acute diarrhoea[97]. Treatment with the traditional diet, composed of rice, lentils cooked with cotton seed oil as part of ORT in severe acute diarrhoea in Pakistani children, indicated that early feeding of the traditional diet "Khitchni" and WHO ORS alone in the first 24 hours was effective[98]. The efficacy of rice to complement a cow-milk based diet in the nutritional management of infants with acute diarrhoea was satisfactory. The Nutrition Research Centre in Houston, United States, claimed that rice cereal is well absorbed by young infants

with acute diarrhoea and that it is an adequate nutrient supplement for them[99].

A study in Bangladesh found that the feasibility of home treatment of diarrhoea with packaged rice-ORS was not apparent although fewer rice - ORS packets were used/episode[103].

Evaluation studies of malto-dextrin/glycine oral rehydration solution[100] and maltodextrin containing oral rehydration solution[101,102] demonstrated that maltodextrin, maltodextrin/glycine containing ORS had no advantage over WHO - ORS and its efficacy might actually be less than that of the standard solution.

Strategic issues for implementation of cereal-based ORT in National Diarrhoeal Disease Control Program was discussed by the International Child Health Foundation, Columbia, United States. The discussion included safety, osmolality, hypernatremia, spoiling, effectiveness, rehydration activity, reduction in stool volume, duration, nutritional effect, effect on food intake, acceptance and usage by care givers, training of health workers, self - reliance of families, effect on other child survival activities, costs, potential problems in changing to cereal - based ORS and the rate of industrial production in packaged cereal - based ORS[104].

2.12 Other Food Ingredients:

A study by the United Kingdom Nutritional Consultative Panel, taking into consideration the nutritional and health

benefits of milk and milk products, stated that the protection by milk against various gastrointestinal disorders i.e. diarrhoea, still needs to be proven[110]. Other studies included the introduction of a soy-based, lactose free formula from the beginning of therapy for acute diarrhoea in children treated as outpatients. It was found safe and shortened diarrhoea duration while maintaining adequate caloric intake[111]. The efficacy of management of infantile diarrhoea by introducing lactose-free diets empirically from the time of diagnosis in addition to the conventional rehydration therapy in South Africa was studied. The study concluded that breast-feeding should be continued during the episode of infantile diarrhoea and that emperical use of soya preparation from the time of hospital admission was not justified and should be considered in infants passing reducing sugars in their stool or in those whose purging rates goes up[112].

2.13 Amino Acid - Based ORS:

Glycine-based ORS was not found to be clinically superior to the WHO - ORS solution in the treatment of acute diarrhoea and added to the cost of production[105,106]. The same results were obtained by maltodextrin/glycine/glycyl - glycine electrolyte ORS compared to glucose ORS[107]. Impact of analine - based ORT (30 mmol/l) for infants with acute diarrhoea[109] demonstrated no significant difference in the outcome of the infants with acute diarrhoea compared with those fed the standard ORS.

## 2.14 Home Promotion of Health and Prevention of Diarrhoeal Diseases:

Sir Thomas Browne's Quotation "Charity begins at home is the voice of the world".

Infancy diarrhoea is a disease of poor hygiene if the mother is not breast-feeding. Many infectious agents may be responsible including rotavirus, coronavirus, other enteriviruses, enterotoxagenic, Escherichia coli, salmonella and Giardia lamblea. Attacks are often associated with bottle instead of breast-feeding and with weaning. Most attacks are self-limiting within a few days, but if diarrhoea and vomiting are severe death may follow as a result of dehydration.

Infantile diarrhoea is the most important single cause of malnutrition in the tropics[113]. Therefore, any attempt to improve child-care practices and the hygienic environment for the child should focus on "MATERNAL" literacy and simple health messages. Availability of safe water, adequate means of human waste disposal for all homes, effective tool for health education of all health workers about diarrhoea are the most important factors for prevention of diarrhoea. The Programme for Control of Diarrhoeal Diseases, WHO (1992) advocated three basic messages for home treatment of diarrhoea:

1- To give the child more fluid than usual to replace the fluid lost in diarrhoea, and thus prevent dehydration.

2- To give the child plenty of easily digestible food

avoiding bulky food and whole grain cereals. The diluted soups must be avoided because they fill the child without providing enough nutrients, and to avoid a lot of sugar which worsen diarrhoea. Food must be cooked well i.e. by fermentation, grinding to make it easy for digestion. Measures to avoid contamination of food must be taken and special attention given for feeding the child during and after diarrhoea.

3- The mother should bring the child to the hospital if the child does not get better in three days, or develops many watery stools, repeated vomiting, marked thirst, eating or drinking poorly, fever, blood in the stool[19].

Rohde and his colleagues[114] declared that potassium losses are high, especially in infant diarrhoea. The optimal rehydration fluid contains a minimum of 20 meq/litre (WHO formula) with higher concentration advocated in several studies. Hypokalemia is associated with apathy, decreased appetite, adynamic ileus, and general disturbance of smooth muscle system, especially in the early rehydration stage. So replacement is an important part of both electrolyte and nutritional therapy. They suggested that a local source of high potassium food must be identified, to encourage their use during home rehydration and convalescence and to study the association between low body potassium on appetite[114].

## 2.2 Adansonia digitata:

### 2.2.1 Introduction:

Adansonia digitata, the baobab, is a well known tree almost everywhere in tropical Africa. In Sudan, the local name is "Tabaldi" tree. The tree is mostly found leafless throughout the season, expressing the longer pendular fruits in the branches, that is why it is called Africa's "upside down tree". A number of other names are given such as "vegetative elephant", "prehistoric plant monument", "abode of the gods" etc.

Several varieties of the genus Adansonia exist in Madagascar and in Australia[115,116].

The baobab is one of the biggest and oldest living creatures attributed with supernatural powers and spirits. Many people in Africa express deep religous veneration, for this outstanding tree is belived to recure its strength from heaven. It is remarkable that nearly every part of the plant has one or several uses in local medicine[115], Indian medicine[116], and in Senegalese traditional medicine[117].

The multiple use made of this tree have further ensured its special place in African culture. Only few other trees approach its significance. It often serves as a prefered place for markets, meetings or other social events.

2.2.2 Vital statistics of baobab tree:

A study on the vital statistics of the baobab tree population in Zambia, Sudan, Mali, Kenya and Tanzania showed that the population appear to be much younger than has generally been believed and only very few trees live to ages in excess of 400 years. Mortality rates vary from 1.1-3.7 per year in the different areas[124]. It is noted that young trees are rarely found. One reason for this is the intensive browsing of young plant by livestock and the excessive use of leaves for food by people. The maximum attainable age is presumed to be between 1000 and 3000 years[116].

2.2.3 Distribution in Sudan:

It is found in central and western Sudan. In the Fung, with rainfall 600-1000 mm, in sandy soil and by Khors in short grass savanna. It forms a belt in central Sudan, Kordofan, Darfur, Blue Nile, Upper Nile and Bahr El Ghazal.

2.2.4 Baobab fruit:

The fruits are capsules, ellipsoid, avoid or globor 15.2 cm long, 4.5-8 cm in diameter, numerous yellowish-brown seeds are embeded in a dry acid edible pulp.

In Sudan, the fruit is known locally as "Gonglase". The trees flowers in June-July and the fruits ripens in January-February.

2.2.5 Chemical composition.

In Sudan, the chemical composition of the fruit pulp was

as follows (Mean ± S. D, dry basis). Total soluble solids 79.3±1.2, alcohol insoluble solids 57.3±2.4, total sugars 23.2±0.2, reducing sugars 18.9±0.5, total pectin 56.2±0.9, protein 2.6±0.3, fat 0.2±0.01, crude fibre 5.7±0.2, ash 5.3±0.02, ascorbic acid 300±6.2 (mg/100g), iron 8.6±1.1 (mg/100g), calcium 655±34 (mg/100g), phosphate 50.8±4.6, moisture 6.7±0.03, pH 3.3±0.04[134].

Baobab fruit pulp is a rich source of calcium[128]. In Malawi the fruit pulp was found to have the highest ascorbic acid content out of twenty two wild fruit species (179 mg/100g)[129]. In Nigeria the concentration of baobab ascorbic acid was found to be 337.0 mg/100g and the fruit is used as sweetener for many local foods and as curding agent for milk[130].

In Sudan the seed was found to contain 19% oil[132], and further studies in Nigeria reported the presence of beta-carotene[133]. The unsaponifiable portion of the oil extracted from the root bark contained beta-amyrin and beta-sitosterol[116].

Phytochemical study of Adansonia digitata identified the presence of friedelin, lupeol, bauerenol, beta-sitosterol and scopoletin in the leaf and the bark. The bark also yielded betulinic acid and the leaf traxerone and the acetates of bauerenol and lupeol[122].

2.2.6 Uses:

2.2.6.1 In traditional medicine:

A study on the anti-infectious phytotherapies of the Adansonia digitata in Senegal (West Africa) related the traditional (medicinal) uses of the tree with the presence of pharmacologically active substance[117].

In the Sahel (Africa) some people call the tree "mother of the sahel". More than thirty different uses are known. The fruit is used for management of malaria, febrifuge, smallpox, measles, dysentery, wound disinfection, eye lotion and general fatigue of children. Smoke from burning the fruit pulp is an insect repellent.

The seed is used as antidate (Cardiotonic) and is also used for dental disorders.

The leaves are used for treatment of guinea worm sores, insect bites, prophylactic against fever, coughs, diuretic, kidney and bladder diseases, dysentery, diarrhoea, gastroentitis, ulcers, inflammation, colics, fatigue, poultices and as a diaphoretic. While the root is used for treatment of malaria, smooth skin for babies[115].

Two other important studies, one from India and the other from Nigeria throw light on the constituents of Adansonia digitata root bark. Ramesh et al. from India stated that in Indian medicine the root bark of baobab is used as antipyretic, febrifuge, astringent in diarrhoea and dysentery,

and as a substitute for Cinchona sp.[116]. It may be of interest to the scientists to find out the relationship between malaria and traditional medicine. Malaria is treated with baobab in Indian medicine where it substitutes Cinchona sp. Quinine the original treatment for malaria (its first recorded use in Peru in 1600 and remains the drug of choice for cerebral and other forms of complicated malaria) is extracted from the bark of Cinchona sp.

The drinking of an aqueous extract of the bark of A. digitata is used in Nigerian traditional medicine as a treatment for sickle cell anaemia. However, in vitro studies did not justify the use of A. digitata for the prevention of sickling cells[115,123].

2.2.6.2 As food/fodder (leaves, soft wood, fruit):

Young leaves give a tasty spinach. Young dried leaves are pulverized and used as a thickening ingredient in many dishes. It has been estimated that several thousands of tons of fresh and dried leaves are consumed annually in the Sahel. The leaves are a favourite forage especially at the beginning of the rainy season. The spongy and very soft wood ha limited use, in cases of extreme water scarcity it is chewed by man and animals.

The young branches are used for fodder and the bark is used for ropes making. Tests carried out at the Forestry Research Institute at Soba (Sudan) have shown that if the wood

is left to disintegrate in water for about two months, it will give a long fiberous material that can be used for packaging. Younger sprouts and the root of young plants are used as famine food[119,120,121].

2.2.6.3 Hallowed out trunk:

In Western Sudan the hollowed out trunk is used for water storage and may also serve as grain stores[115].

2.2.6.4 Processing of Adansonia digitata:

A study on the effect of processing methods on the chemical composition of baobab pulp and seed in Nigeria revealed that a 6-day fermentation appears to be the most promising method for producing nutritious food from baobab compared with roasting as judged by crude protein, moisture and minerals[125].

In a small production unit in Burkina Faso, two women produce monthly 500 bags of 500g Misola flour from millet 50%, Soy 30% and groundnuts 10% with sugar, salt and dried baobab leaves or yeast. The flour is used specifically to feed underweight children[126]. In Tanzania a study displayed a number of products derived from Adansonia digitata[120].

A study for the utilization of A. digitata fruit pulp by the soft drink industry in Nigeria showed fast deterioration of the fruit pulp even when exposed to a limited supply of humid air. This occured even when each pulp was kept intact in the pod. Addition of sodium metabisulphite which effectively

reserved the pulp against heat and light effects was uggested[131].

# CHAPTER III

## MATERIALS AND METHODS

### 3.1 Materials:

*Adansonia digitata* fruit was brought in January 1994 by the Agricultural Research Corporation, Western Sudan Agricultural Research Station from "ELsatta" west of Elobied to the Food Research Centre for the study. The fruit was of the 1993/94 season.

#### 3.1.1 Preparation of the Sample:

The fruit capsule was broken, the pulp was separated from the seeds, mixed and packaged immediately in black polyethylene sachets and stored in a desicator.

#### 3.1.2 Physical Properties of the Fruit:

A vernier caliper was used to measure the fruit dimensions and the thickness of the fruit capsule.

### 3.2 Methods:

3.2.1 Moisture, ash, protein and tannic acid contents were determined according to the AOAC methods (1970).

3.2.2 The mineral contents were determined by X-ray fluorescence[135].

The irradiation of the sample was for 1000 seconds and the analysis by the computer took about 10 minutes. The sample was prepared in pellet form. A special standard was prepared for the analysis of the sample using pure oxides of the elements to be measured.

3.2.3 Ascorbic acid content:

Ascorbic acid was determined according to the method described by Pearson (1976)[136] by titration of the sample with standard 2,6, dichlorophenolindophenol. The vitamin content was expressed in mg/100g.

3.2.4 Nicotinic acid:

Nicotinic acid was estimated by the calorimetric method described by Carlson (1966) and modified by Magboul (1981)[137,138].

3.2.5 Determination of Thiamine, Rhiboflavin and Pyridoxine:

High pressure liquid chromatography (HPLC) was used for the determination of these vitamins in baobab pulp. Powdered baobab pulp was dissolved in acidic water ($H_3PO_4$) and filtered. The pH of the sample was 2.8 and its concentration 250 mg/5 ml. Standard concentrations were 6 ppm for vitamins $B_1$, $B_2$ and $B_6$. The instrument was a Varian - star with the PDA varian detector 9065. The column was a Bondesil CIB (4.6 x 150 mm) set at a temperature of 40°C. The mobile phase A (water containing 0.1% $H_3PO_4$ and 0.01 TEA) and B. ACN. The flow rate was 0.6 ml/minute. The injected volume was 10 µl. The percentages were calculated by peak areas.

3.2.6 Determination of baobab sugar content:

High performance liquid chromatography (HPLC) was used for the determination of the sugar content in baobab pulp. Varian 5500 ternary gradient pump system with shimadzu Rid-6A,

refractive index detector and vista -402 data station were used. Bondsil $NH_2$ column (4.6x250 mm) was used. The temperature set at 30°C and the mobile phase 78:22 (Acetonitrite:Water). The flow rate was 0.7 ml/minnute.

Five standards (fructose, glucose, sucrose, maltose and lactose) were injected and the chromatogram was recorded. A filtered baobab pulp solution (2%) was analyzed. The presence of fructose, glucose and sucrose was confirmed by comparing retention times with the standards. The percentages' were calculated by peak areas.

3.2.7 Preparation of baobab oral rehydration solutions:

The fruit capsules were broken and the fruit released and weighed immediately in small black polyethylene bags which were moisture-proof and the bags were closed. Three types of formulated baobab solutions were prepared for distribution to children with mild diarrhoea.

Each black polyethylene bag containing 80g of baobab fruit was distributed to children with diarrhoea for early home management of diarrhoea and prevention of dehydration. Each bag was used for preparing one of the three solutions. Two polyethylene bags, each containing 3.5g table salt (NaCl) and 40g sugar were distributed with solution B, while only the polyethylene bag of sugar was distributed with solution A.

Solution A:

80g of baobab + 40g sugar/l of water.

Solution B:

80g of baobab + 3.5g salt (NaCl) + 40g sugar/1 of water.

Solution C:

80g of baobab + ORS/1 of water.

Solution D:

Standard WHO/UNICEF recommended oral rehydration solution (ORS)/1 of water.

3.2.8 Preparation of the solutions:

The children parents were advised to prepare the solution at home using the distributed pre-weighed packges as follows:

1- Hands were to be washed with soap and water.

2- The baobab fruit content of one black polyethylene bag was poured into a clean container.

3- Clean boiled water (6 tea cups) to make one litre of the baobab extract was added to the container.

4- The content were well mixed until the fruit dissolved and the baobab extract was filtered through a normal household filter.

5- The packet containing the weighed sugar was added in case of solution A, and the two packets containing the salt and sugar were added in case of solution B. For solution C the standard WHO/UNICEF ORS was added. The control solution D was prepared by adding one packet into a previously boiled and cooled clean water. All the solutions were brought up to one

litre.

Fresh solutions were prepared each day in a clean covered container and used for only one day. The residual solution was thrown. Mothers were asked to give the solutions by cup and spoon.

Random samples of prepared solutions A, B, C and D were analyzed for osmolality and electrolyte content.

3.2.9 The analysis of osmolality:

The osmolality of solution A, B, C and D were analyzed using an electric semi-mirco osmometer (Halbmikro osmometer).

The osmotic pressure of a solution is a function of the total dissolved substances in that solution. The osmotic pressure of a liquid is proportional to the depression of the freezing point of the solution.

Calibration of the instrument:

Calibration was performed with distilled water for zero milliosmol/kg and for 400 millosmol/kg. Calibration solution was prepared by dissolving 12.687g of analytical grade NaCl in one litre of water at 20°C.

3.2.10 The determination of electrolytes:

The electrolytes sodium and potassium of the administered solutions were determined using Corning 400 flame photometer.

Na meq/l = [flame reading x dilution factor]/[10 x 23]

K meq/l = [F.R x D.F]/[10 x 39]

3.3 Place of the study and study sample:

3.3.1 Time and duration:

The study was carried out in Khartoum North at Khatmia Health Center, Shabia Health Center and Ahmed Gasim Children's Teaching Hospital from January 1994 to December 1994.

The patients were inspected by a physician and those with mild diarrhoea or dysentery and taking medicine were referred to the author. A verbal consent was obtained from parents before children were enrolled in the study. The supporting staff were the nutritional advisors.

3.3.2 Inclusion criteria:

Children younger than 5 years of age with watery diarrhoea (defined as passage of liquid or watery stool, more than three times in a day), and those with dysentery and taking medicines and with no dehydration or some dehydration were included in the study.

3.3.3 Exclusion criteria:

The exclusions were children less than 6 months old, those with systemic disease, severe dehydration and those with moderate or severe protein-energy malnutrition.

3.3.4 Study population:

For children satisfying the inclusion criteria questionnaire 1 was filled. The questionnaire included the following details:

- The economic and social status of the family.

- Record data on the child.

- The criteria of assessing the efficacy of the adminstered solution every day for three successive days.

A total number of children aged 6-60 months, suffering from mild diarrhoea with no or some dehydration. Thirty two children were given solution A, 35 children solution B, 25 children solution C and 21 control children were given solution D.

Incentives in the form of flour and sugar were given to children's mothers taking solution D to encourage them for the follow up. Children from any of the four groups who did not follow up for three successive days were excluded from the analysis.

3.4 Evaluation of the children with diarrhoea:

The mothers were interviewed and the questionnaire was completed for each child. The interview was repeated daily for three successive days of using the administered solutions. The mothers were encouraged to continue breast-feeding. No medicines were given during the study period except for those with dysentery.

3.5 Statistical analysis:

The analysis of the data was performed using Commodor (1930) compatible P.C statistical package for social science (SPSS) V5.O.I for the PC. Data entry (ASCII format). The mean and the standard deviation (SD) were calculated for all

quantitative data . Student t-test was used to compare between means, Chi-square test was used to determine whether the observed frequencies of individuals with given characteristics differed significantly from what was expected, multiple range test (Sheffe procedure) was used to compare between variables.

# CHAPTER IV

# RESULTS

## 4.1 Results of physicochemical characteristics of Adansonia digitata fruit:

### 4.1.1 Physical Characteristics of Baobab Fruit:

The edible fruit pulp is enclosed in a woody fruit capsule which is oblong and slender with different sizes 12-27 cm long, 4.6 - 10.5 cm in diameter. Table 1 shows the mean values for fruit capsule size, thickness of the woody capsule and the ratio of the weight of pulp to that of the seed.

### 4.1.2 Chemical Characteristics of Baobab Fruit Pulp:

Table 2.1 illustrates the chemical composition of the baobab fruit pulp while Table 3 gives the mineral content of the baobab fruit pulp as estimated by X-ray fluorescence. Table 4 shows the vitamin content of the fruit pulp. Ascorbic and nicotinic acids were determined by titration and colorometric methods while pyridoxine was determined by HPLC.

Figure 1 illustrates the HPLC separation of the standard mixture of vitamins $B_1$, $B_2$, and $B_6$ while Fig. 2 shows the separation of vitamin $B_3$ in the fruit pulp. On comparing this chromatogram with the standard chromatogram, the other two peaks shown in the sample chromatogram at retention times 9.442 min. and 11.370 min. have some resemblance to $B_1$ (thiamine) and $B_2$ (riboflavin) standards'

Table 1 Physical characteristics of baobab fruit pulp.

| Character | Mean ± S.D |
|---|---|
| Fruit capsule length (cm) | 19.5 ± 4.4 |
| Width (cm) | 7.1 ± 1.5 |
| No. of seed/100g fruit | 176.0 ± 17 |
| Thickness of the fruit capsule (cm) | 0.59 ± 0.05 |
| percentage wt. of pulp | 34 ± 2 |

Table 2 Chemical composition of baobab fruit pulp (%).

| Constituent (dry basis) | Mean (%) ± S.D |
|---|---|
| Moisture | 4.2 ± 0.2 |
| Ash | 5.7 ± 0.2 |
| Protein (%N x 6.25) | 2.6 ± 0.2 |
| Fat | 0.2 ± 0.01 |
| Tannin as tannic acid | 0.5 ± 0.05 |

Table 3 Mineral content of baobab fruit pulp.

| Mineral | Content (ppm) |
|---|---|
| K | 450 |
| Ca | 670 |
| Ti | 865 |
| Cr | 297 |
| Mn | 67 |
| Fe | 53 |
| Ni | 55 |
| Cu | 15 |
| Zn | 10 |
| Se | 10 |
| Br | 4 |
| Rb | 3 |
| Sr | 2 |
| Y | 4 |
| Zr | 1 |
| Pb | 6 |

(ppm: μg/g)

Table 4 Vitamin content of baobab fruit pulp

| Vitamin | Content (mg\100g) |
|---|---|
| Ascorbic acid | 335 |
| Free nicotinic acid | 50 |
| Pyridoxine | 10 |

Table 5 Sugar content of baobab fruit pulp as determined by HPLC.

| Sugar | % |
|---|---|
| Fructose | 2.6 |
| Glucose | 2.9 |
| Sucrose | 12.8 |

Figure 1 HPLC seoaration of a standard mixture of vitamins $B_1$, $B_1$ and $B_6$.

(Figures indicate retention times)

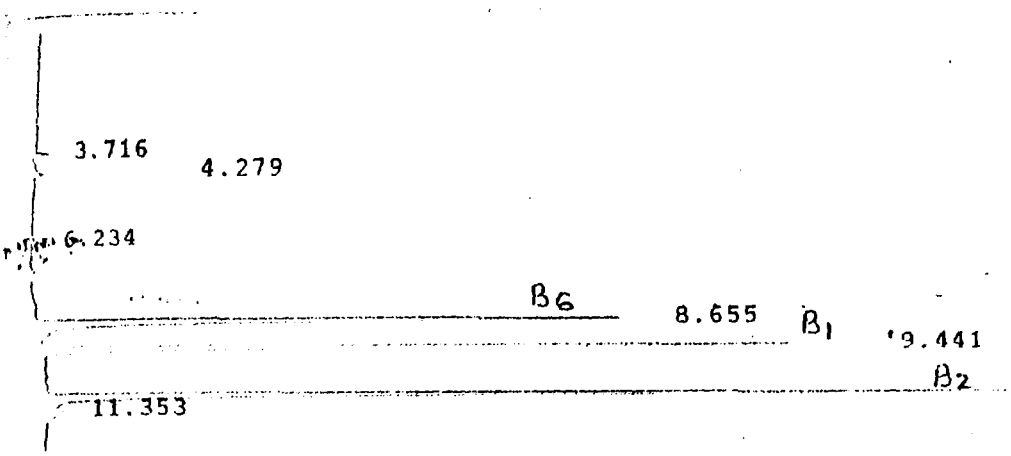


Figure 2 HPLC separation of vitamins B of baobab fruit pulp.

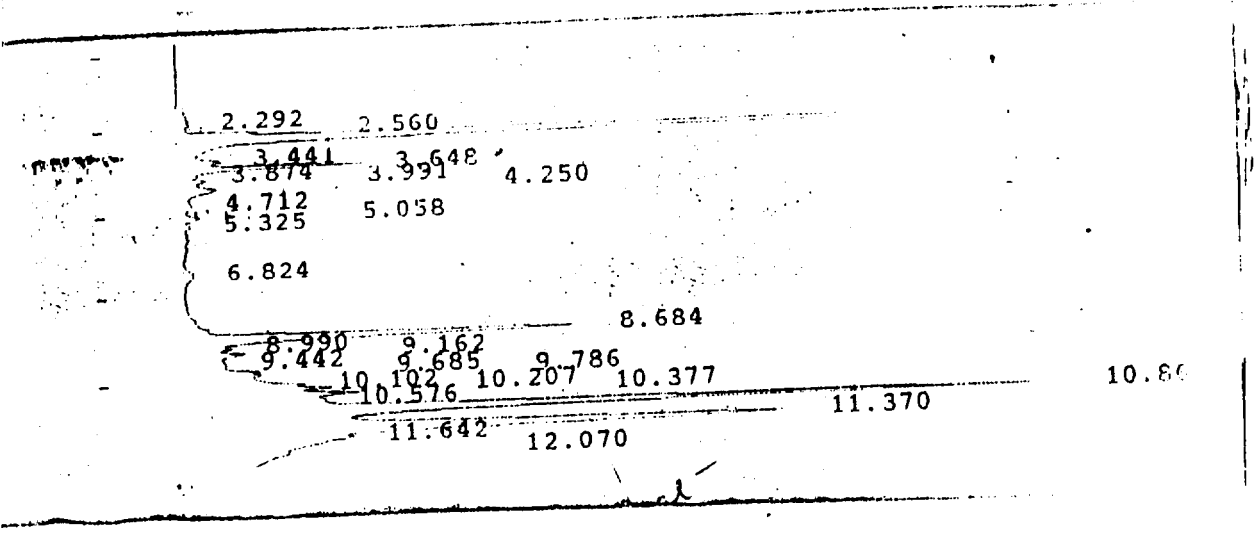
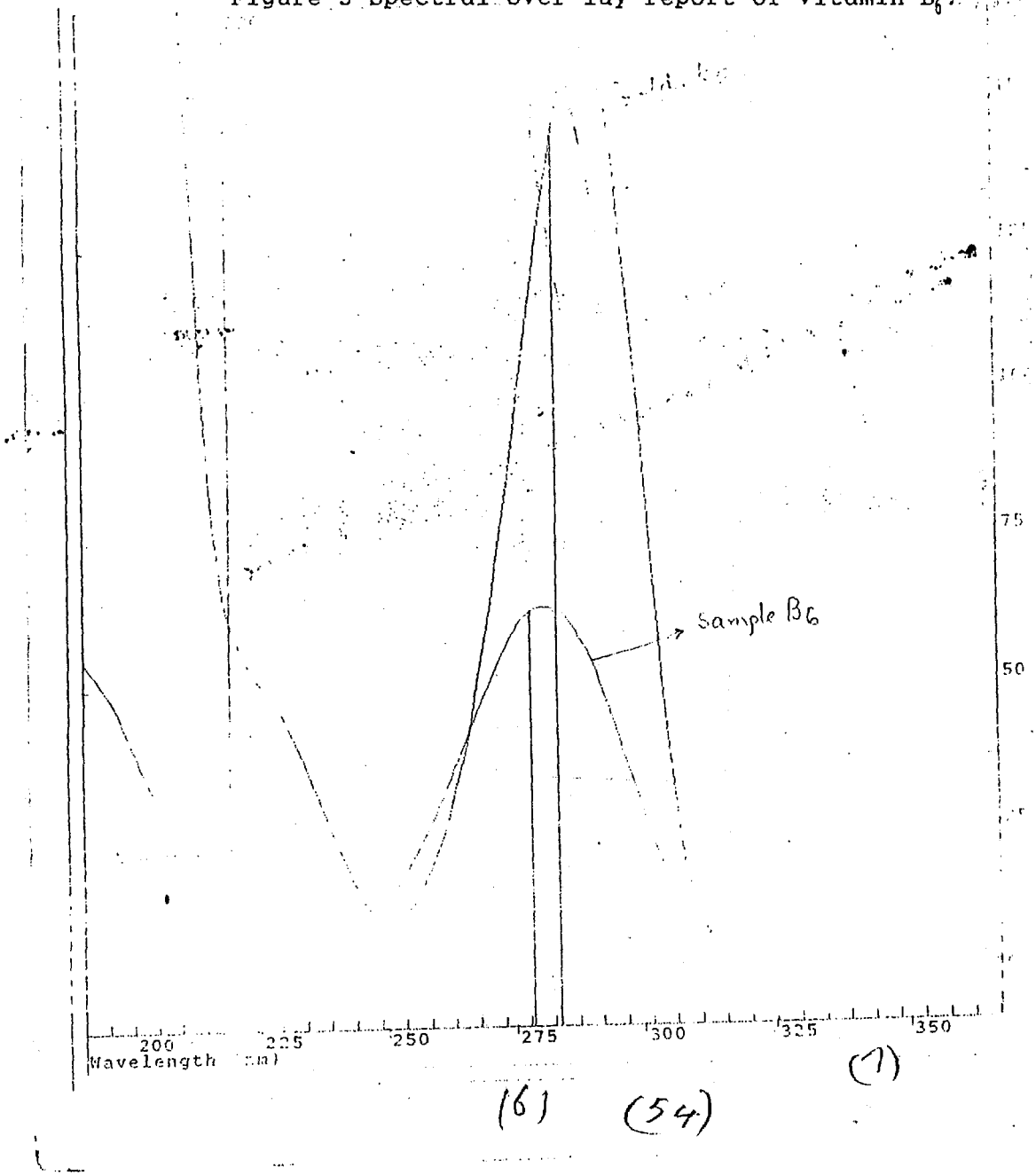


Figure 3 Spectral over lay report of vitamin $B_6$.



etention times at 9.441 and 11.353 respectively. However, fter configuration via photodiode array detector, they were ound to be different from the chromatogram of the standards. ence, $B_1$, and $B_2$ were confirmed not to be present in the ample of the baobab fruit pulp. Vitamin $B_6$ (pyridoxine) had n approximate value of 100 ppm.

Table 6 shows citrate as the base precursor of the ontrol ORS. The standard ORS and solution C baobab-based ORS ere hyperosmolar (Table 7). Solution B had normal osmolality hile solution A was hypo-osmolar.

Table 8 illustrates the energy content of the home oral ehydration solutions calculated as follows:
he baobab solution contains 80 g of baobab per 1000 ml of ater which is equal to 27 g of the pulp (2:1) (seed/pulp atio), 27 g of the pulp contain 2.6% protein, 0.2% fatty cid, 18.3% total sugar.

.2 Results of the Clinical Trials on Patients (home application of Oral Rehydration Solution):

.2.1 General Consideration:

The total number of patients included in the study was 13, allocated randomly to 4 groups as follows:
olution A 32 patients, solution B 35 patients, solution C 25 atients and solution D (standard ORS) 21 patients, as shown n Table 9. Male and female patients were included in the tudy.

Table 6 Composition of the distributed standards ORS by weight

| Ingredients | g |
|---|---|
| Anhydrous glucose | 20.0 |
| Sodium chloride | 3.5 |
| Trisodium citrate dihydrate | 2.9 |
| Potassium chloride | 1.5 |

Table 7 Osmolality and electrolyte content of home oral rehydration solutions

| | Solution A | Solution B | Solution C | Solution D (control) |
|---|---|---|---|---|
| Sodium (mmol/l) | 1.37 | 50.87 | 92.00 | 90 |
| potassium (mmol/l) | 21.60 | 21.60 | 43.00 | 20 |
| Osmolality | 170 | 282.5 | 337.5 | 311 |

Table 8 Calculated energy content per 100 ml of the rehydration solutions

| Rehydration solution | Energy content kcal/100 ml |
|---|---|
| Solution A | 18.3 |
| Solution B | 18.3 |
| Solution C | 10.3 |
| Solution D | 08.0 |

Table 9 Rehydration solution administered to the children with diarrhoea

| Rehydration solution | Frequency (%) |
|---|---|
| Solution A | |
| (80g Baobab + 40g sucrose) | 32(28) |
| Solution B | |
| (80g baobab + 40g sucrose + | 35(31) |
| 3.5g table salt (NaCl)) | |
| Solution C | |
| (80g baobab + ORS sachet | 25(22) |
| Solution D (control)) | |
| (ORS sachet) | 21(19) |
| Total | 113 |

Table 10 Distribution of children by age groups in the study

| Age (Months) | A n = 32 | B n = 35 | C n = 25 | D n = 21 |
|---|---|---|---|---|
| 12 | 19 | 16 | 11 | 14 |
| 13-24 | 9 | 16 | 12 | 5 |
| 25-36 | 3 | 2 | 2 | 1 |
| > 36 | 1 | 1 | | 1 |
| Mean ages (±SD) | 15.375 (9.714) ** | 16.143 (10.276) ** | 14.8 (6.640) ** | 13.95 (7.536) |

.2.2 Age of Children:

Table 10 shows the distribution of children by age roups. Most of the children were in the range of 7-24 months. here was no significant difference between the mean ages of hildren in the different groups and the control group.

.2.3 Socioeconomic Background of Families:

.2.3.1 Age:

A higher proportions of the fathers (49.5%) and the ajority of the mothers (76.1%) of the children were in the 5-35 years age group (Table 11)

.2.3.2 Area of origin of Parents:

Most of the fathers and mothers were from the northern art of Sudan (Table 12). None of the fathers were from the stern part and only 5% of the mothers.

2.3.3 Education of Parents:

Most of the parents recieved secondary education Table 13). The education of parents in groups A and D showed gnificant difference ($P<0.05$) but not that of parents in oups B and C ($P>0.05$).

2.3.4 Occupation of Parents:

Statistical analysis (Table 14) showed that there was no gnificant differences in the occupation of fathers of group B and D. The difference is significant in group C fathers. e mothers showed siginificant differences in the different oups.

Table 11 Age of parents.

| Age (Years) | A n = 32 | B n = 35 | C n = 25 | D n = 21 |
|---|---|---|---|---|
| Fathers | | | | |
| < 25 | 2 | - | 1 | - |
| 25-35 | 13 | 14 | 14 | 15 |
| 36-45 | 16 | 17 | 7 | 4 |
| > 46 | 1 | 4 | 3 | 2 |
| Mean ages (±SD) | 36.967 (5.666) ** | 39.857 (7.949) * | 36.667 (8.874) ** | |
| Mothers | | | | |
| < 25 | 1 | 3 | 7 | 5 |
| 25-35 | 29 | 28 | 15 | 14 |
| 36-45 | 2 | 4 | 3 | 2 |
| Mean age (± SD) | 28.219 (4.871) ** | 30.00 (6.660) * | 36.833 (6.90) ** | 25.857 (6.552) |

Table 12. Area of origin of parents.

| Area | A (%) | B (%) | C (%) | D (%) |
|---|---|---|---|---|
| Fathers: | | | | |
| South | 3 | 7 | 15 | 13 |
| North | 72 | 60 | 42 | 56 |
| East | – | – | – | – |
| West | 25 | 33 | 42 | 31 |
| Mothers: | | | | |
| South | 3 | 6 | 10 | 13 |
| North | 69 | 17 | 43 | 50 |
| East | – | – | 5 | – |
| West | 28 | 36 | 38 | 38 |

Table 13 Education of parents.

| Area | A | B | C | D |
|---|---|---|---|---|
| | No (%) | No (%) | No (%) | No (%) |
| Fathers: | | | | |
| Illiterate | - | 1(4) | 1(5) | - |
| Primary | 1(4) | 5(22) | 5(26) | 3(15) |
| Intermediate | 4(15) | 7(20) | 6(32) | 3(15) |
| Secondary | 12(46) | 6(26) | 7(37) | 12(60) |
| Higher education | 9(35) | 4(17) | - | 2(10) |
| $X^2$ | * | ** | ** | * |
| Mothers: | | | | |
| Illiterate | 2(7) | 2(8) | 2(12) | 1(6) |
| Primary | 3(10) | 9(36) | 5(29) | 4(24) |
| Intermediate | 10(35) | 6(24) | 7(41) | 3(18) |
| Secondary | 10(35) | 7(28) | 3(18) | 4(53) |
| Higher education | 4(13) | 1(4) | - | - |
| $X^2$ | * | ** | ** | * |

Table 14 Occupation of parents.

| Occupation | A | B | C | D |
|---|---|---|---|---|
| | No (%) | No (%) | No (%) | No (%) |
| Fathers: | | | | |
| Gov. skilled employee | 8(28) | 6(21) | 1(5) | 3(15) |
| Gov. unskilled employee | 7(23) | 5(17) | 3(14) | 2(10) |
| Skilled labour | 5(16) | 5(17) | 5(24) | 3(15) |
| Unskilled labour | 7(23) | 13(45) | 11(52) | 8(40) |
| Unemployed | 1(3) | - | - | - |
| Soldier | 3(10) | - | 1(5) | 4(20) |
| $\chi^2$ | ** | ** | * | ** |
| Mothers: | | | | |
| Gov. skilled employee | 5(23) | 1(4) | - | 1(6) |
| Gov. unskilled employee | 2(9) | - | 1(5) | 3(19) |
| Domestic | 15(68) | 23(96) | 18(95) | 12(75) |
| $\chi^2$ | * | * | * | * |

4.2.3.5 Sanitory environment:

Figure 4 illustrates the water sources of the different groups in the study. Most of the families had tap water mainly inside their houses. Group B and C had also water from wells, more in the case of group C than B, whether the well were inside or outside the houses.

The highest proportions of families with no latrines were in group B, followed by group C, then the control group D and the least was in group A (Fig. 5). Most of those with latrines had the pit-type. More flush latrins were available to the control group D and the least to group C; group A and B had comparable numbers.

Table 15 shows the social characteristics of parents in the study. The mean age of fathers was 36 years old and the mean age of mothers was 27 years. Most of the parents recieved secondary schooling, about 65% of fathers and 63% of mothers. Only 2% of fathers and 8% of mothers were illiterate. Those who recieved higher education were 17% of fathers and 6% of mothers. Most of the fathers were unskilled labours (39%) whereas most of mothers (84%) were house-wifes. Most of the parents in the study were from northern Sudan (60% of fathers and 34% of mothers), followed by those from western Sudan (32% of fathers, and34% of mothers). None of the fathers originated from eastern Sudan and only one mother.

Undefined level of income recieved by 51% of the fathers.

Table 15 Social characteristics of parents in the study

| Characters | Fathers | Mothers |
|---|---|---|
| A. Mean age in years (SD) | 36.186(10.046) | 27.788(6.859) |
| B. Education | | |
| $B_1$ Illiterate | 2(2) | 7(8) |
| $B_2$ Primary | 14(16) | 21(24) |
| $B_3$ Intermediate | 20(23) | 26(30) |
| $B_4$ Secondary | 37(42) | 29(33) |
| $B_5$ High education | 15(17) | 5(6) |
| C. Occupation frequency (%) | | |
| $C_1$ Gov. skilled employee | 18(18) | 7(9) |
| $C_2$ Gov. unskilled employee | 17(17) | 6(7) |
| $C_3$ Skilled labour | 18(18) | - - |
| $C_4$ unskilled labour | 39(39) | - - |
| $C_5$ Unemployed or house wife sodier | 1(1) | 8(84) |
| D. Area of origin (Sudan) | | |
| $D_1$ South | 8(8) | 8(8) |
| $D_2$ North | 58(60) | 58(57) |
| $D_3$ East | - - | 1(1) |
| $D_4$ West | 31(32) | 35(34) |
| E. Family income (thousands Sudanese pounds) | | |
| $E_1$ 4 - 12 | 41(36) | |
| $E_2$ 13 - 20 | 9(8) | |
| $E_3$ > 20 | 6(5) | |
| $E_4$ Undefined | 57(51) | |

Fig.4 Water sources of different groups in the study

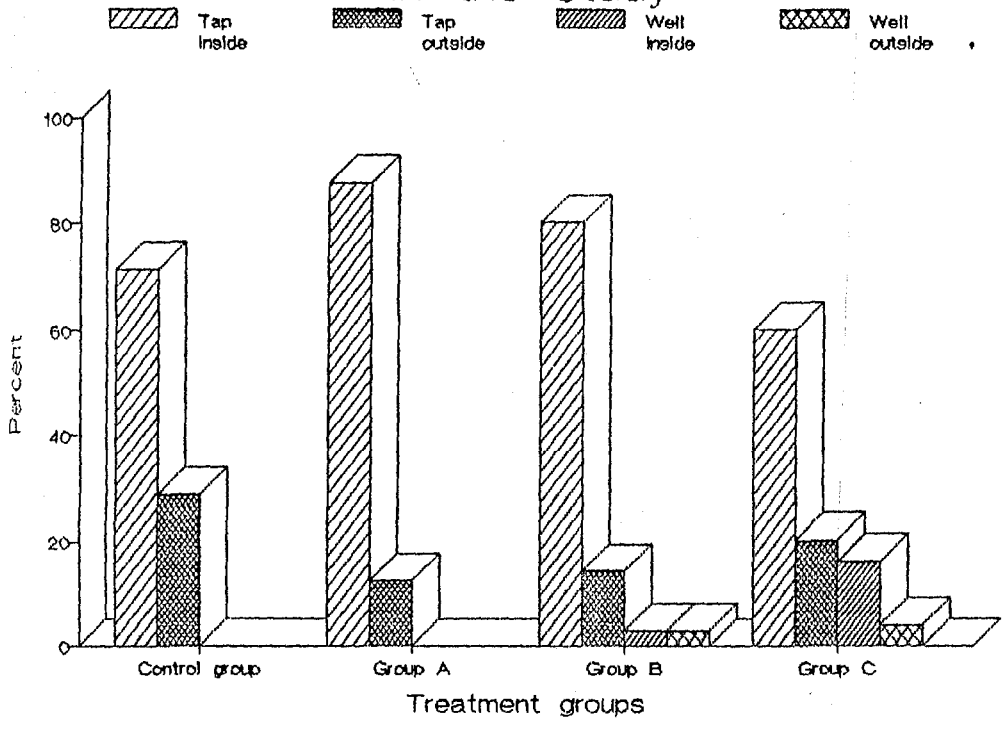


Fig. 5 Latrine type in the study groups

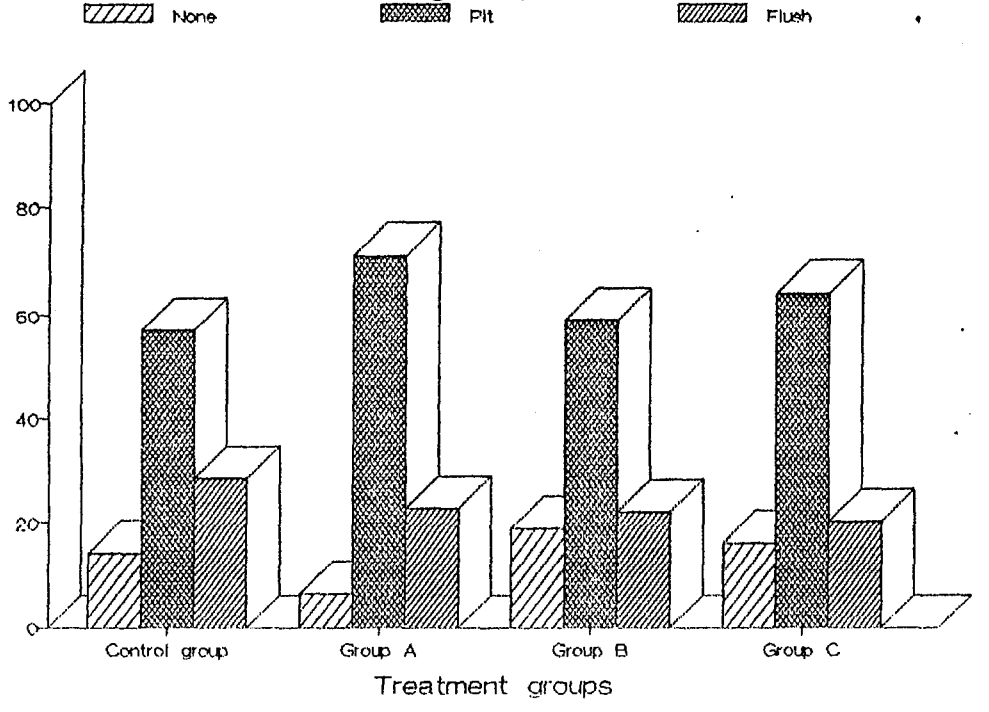
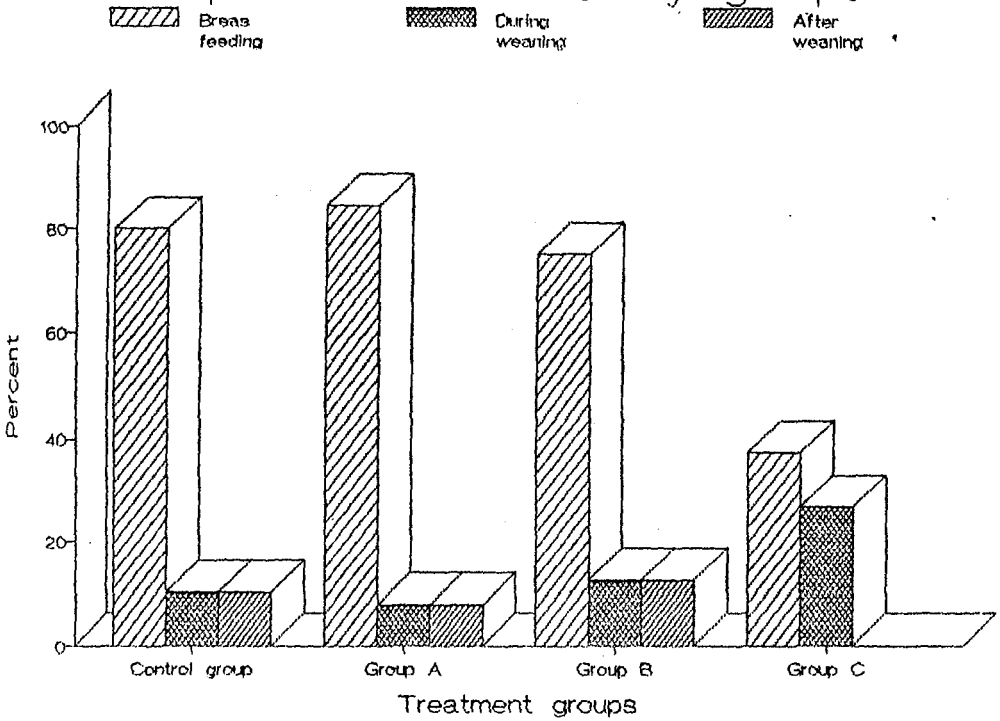


Fig.6 The period of past diarrhoeal episodes in the study groups



4.2.4 Clinical Observations:

4.2.4.1 Introduction:

The total number of children, both males and females included in the study was 113 allocated randomly to 4 groups.

The clinical observations of chlidren in the study groups are shown in Table 16. There was no significant difference between the study groups and the control in mean duration of diarrhoea, mean past diarrhoeal episodes and body weight. Most of the children had normal nutritional status. Only one child was over weight and 28% were under weight.

4.2.4.2 Past diarrhoeal episodes:

Table 17 shows the past history of diarrhoea among children in the different groups. About half of group A (53%), group C (48%), group D (52%) and most of group B, experienced no diarrhoeal attack before.

Table 18 describes the frequency of past diarrhoeal episodes. The most common frequency was 5-7.

Figure 6 shows the period of past diarrhoeal episodes in the study groups. Diarrhoea prevailed during the period of breast-feeding. Compared to the other groups, group C had the highest episodes during weaning and the least after weaning (none).

4.2.4.3 Past Admission to Hospitals:

Table 19 describes the past admission to hospitals of children in the different groups. Most of the studied children were not admitted to hospital before. The main reason for

Table 16. Clinical feature of children in the study groups

| Clinical features | D (control) n = 21 | A n = 32 | B n = 35 | C n = 25 |
|---|---|---|---|---|
| Age mean (months) SD | 13.95 (7.537) | 15.375 (9.714) ** | 16.143 (10.276) ** | 14.80 (6.84) ** |
| Diarrhoea duration mean (hrs) SD | 77.37 (51.1) | 97.23 (135.66) ** | 80.71 (88.32) ** | 125.96 (152.15) ** |
| Past diarrhoeal episodes mean SD | 2.0 (0.756) | 2.4667 (1.407) ** | 2.9091 (1.514) ** | 3.2508 (3.389) ** |
| Body weight mean (kg) SD | 8.1 (1.722) | 7.978 (1.52) ** | 8.61 (2.947) ** | 8.565 (1993) ** |
| Nutritional status | | | | |
| Normal frequency | 17 | 21 | 22 | 20 |
| Under weight frequency | 4 | 10 | 13 | 5 |
| Over weight frequency | - | 1 | - | |

Table 17. Past history of diarrhoea among children in the different groups

| Occurrence Frequency | A No (%) | B No (%) | C No (%) | D No (%) |
|---|---|---|---|---|
| 1 | 5(16) | 1(3) | 6(24) | 2(10) |
| 2 | 3(9) | 6(17) | 3(12) | 4(19) |
| 3 | 4(13) | - | 1(4) | 2(10) |
| 4 | 1(3) | 1(3) | 1(4) | 2(10) |
| 5 | 2(6) | 3(9) | - | - |
| > 5 | - | - | 2(8) | - |
| Not occur before | 17(53) | 24(69) | 12(48) | 11(52) |

Table 18 Frequency of past diarrhoeal episodes in different study groups

| Frequency | A No (%) | B No (%) | C No (%) | D No (%) |
|---|---|---|---|---|
| 3 - 5 | 10(31) | 5(14) | 8(32) | 3(13) |
| 5 - 7 | 16(50) | 23(66) | 12(48) | 11(32) |
| 7 - 9 | 3(9) | 4(11) | 1(4) | 2(10) |
| 9 - | 1(3) | - | 1(4) | 1(5) |

those admitted was whooping cough.

4.2.4.4 Medical Management of Past Diarrhoeal Episodes:

Medical mangement during diarrhoeal episodes in the study groups is illustrated in Fig. 7 Most of the children were treated by the health service staff.

4.2.4.5 Traditional management of past diarrhoeal episodes:

The pattern of traditional management during past diarrhoeal episodes in the study groups is shown in Table 20. Fumigation was practiced by 32% of mothers, blood letting by 11.5%, removal of teeth-buds by 9% and cautery by 3% while 53% of the mothers practiced no traditional management for their children with diarrhoea.

4.2.4.6 Special foods:

Special foods intake during past diarrhoeal episodes were noted (Table 21). Most of children (77%) had taken special foods for management of diarrhoea before. Custard, rice and "Nasha" were the most popular special foods.

4.2.4.7 Past history of feeding pattern:

The pattern of past fluid intake in the study is shown in Table 22. Most of the children had normal fluid intake. Breast milk intake is shown in Fig. 8. Most of the children were breast-fed and their intake during diarrhoea was normal. Most of the children started fresh milk intake at the age of 5-9 months. Formula of powdered milk was prefered in early infancy (0-4 months of age).

'able 19 Past admission to hospitals of children in the different groups

| Admission to hospital | A No (%) | B No (%) | C No (%) | D No (%) |
|---|---|---|---|---|
| Yes | 10(31) | 3(9) | 6(24) | 9(43) |
| No | 22(69) | 32(91) | 19(76) | 12(57) |
| measles | 1(3) | - | - | 1(5) |
| Whooping cough | 4(13) | 2(6) | 6(24) | 7(33) |
| Others | 5(17) | 1(3) | - | 1(5) |

Fig. 7 Medical management during past diarrhoea episodes in the study groups

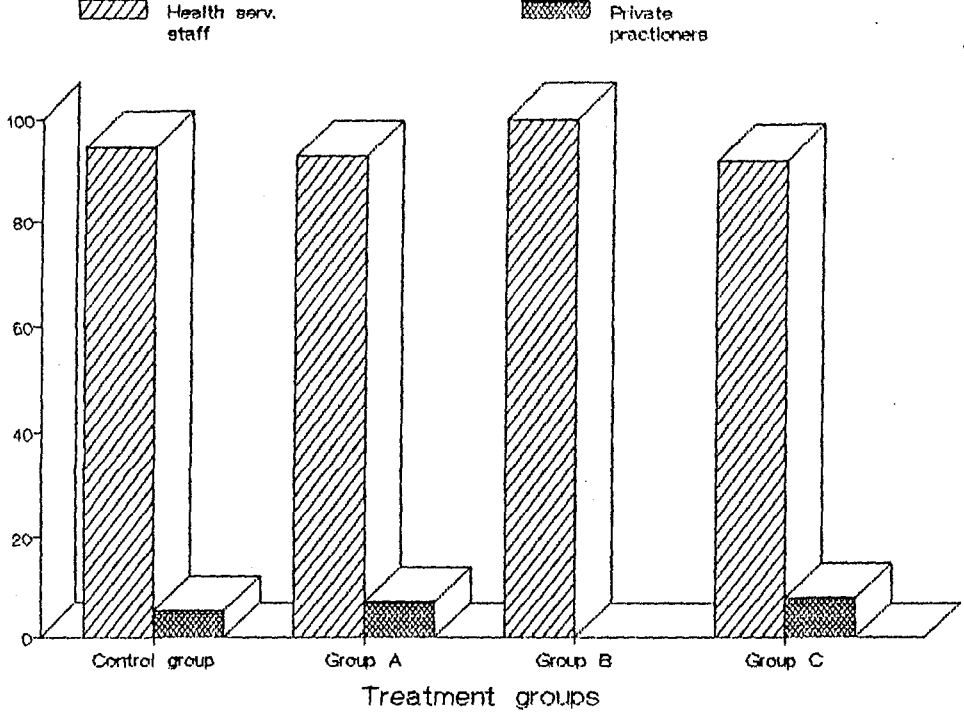


Table 20. Traditional management during past diarrhoeal episodes in the study groups

| Traditional management | A frequency (%) | B frequency (%) | C frequency (%) | D frequency (%) |
|---|---|---|---|---|
| Cautery | 1(3) | 2(6) | - | - |
| Fumigation | 10(31) | 10(29) | 5(20) | 1(5) |
| Blood scarification | 1(3) | - | 2(8) | 1(5) |
| Removal of teeth buds | - | 3(9) | 4(16) | 2(10) |
| Fumigation + removal of teeth buds | - | 1(3) | - | - |
| Cautery + fumigation | - | 1(3) | - | - |
| Blood scarification + fumigation | - | 5(14) | 1(4) | 3(14) |
| No traditional management | 20(63) | 13(37) | 13(52) | 14(67) |

'able 21 Special food intake during past diarrhoeal episodes

| Special food | A frequency (%) | B frequency (%) | C frequency (%) | D frequency (%) |
|---|---|---|---|---|
| Nasha | 7(28) | 2(8) | 2(11) | 3(17) |
| Rice water | 6(24) | 3(12) | 3(16) | 4(22) |
| Custard | 6(2) | 5(26) | 5(26) | 6(33) |
| Herbs | 1(4) | - | - | - |
| Others | 4(16) | 4(16) | 4(21) | 1(6) |
| Rice + custard | 1(4) | 9(36) | 5(26) | 4(22) |
| Children taken special food | 25(78) | 25(71) | 19(76) | 18(86) |

Table 22. Past fluid intake in the study groups

| Fluid intake | A No (%) | B No (%) | C No (%) | D No (%) |
|---|---|---|---|---|
| a) Breast milk | | | | |
| Stopped | - | 4(14) | 3(13) | 2(10) |
| Restricted | 2(8) | 5(17) | 6(25) | 1(5) |
| Increased | - | 1(3) | - | 1(5) |
| Normal | 22(92) | 19(66) | 15(63) | 16(80) |
| b) Fresh milk | | | | |
| Stopped | 4(17) | 3(13) | 3(19) | 1(6) |
| Restricted | 2(9) | 7(30) | 3(19) | 2(12) |
| Increased | 1(4) | 2(9) | - | - |
| Normal | 16(70) | 11(48) | 10(63) | 14(82) |
| c) Powdered milk | | | | |
| Stopped | 1(17) | 1(17) | 2(15) | - |
| Restricted | 1(17) | 1(17) | 1(8) | 2(29) |
| Increased | 1(17) | - | - | - |
| Normal | 3(50) | 4(67) | 10(77) | 5(71) |

Fig. 8 Breast milk intake of children in the study groups

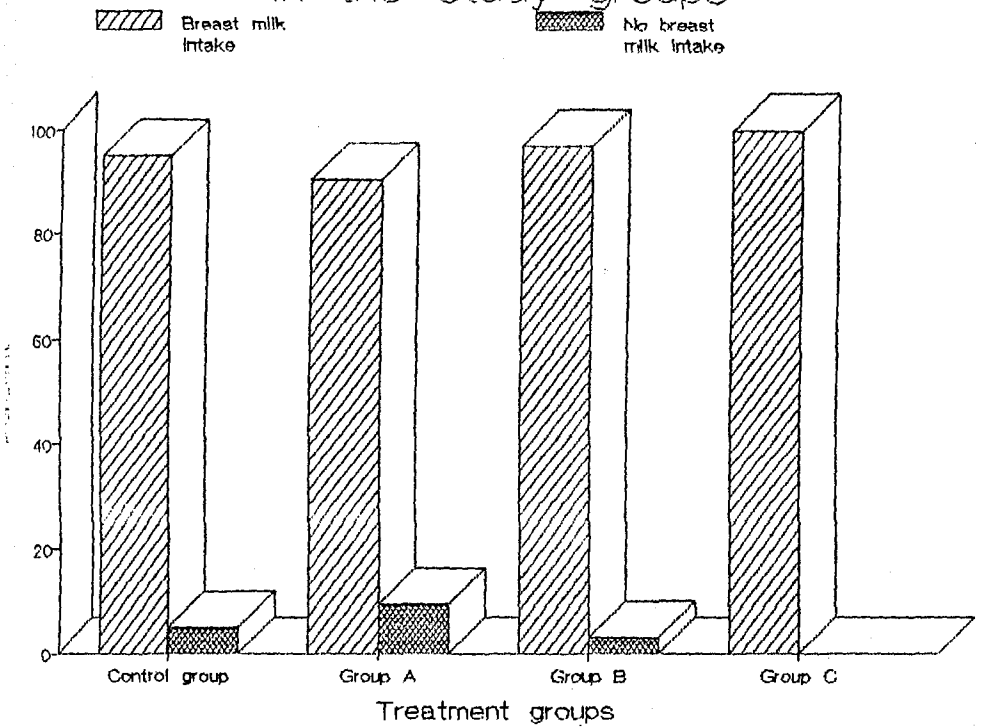


Figure 9 shows that artificial milk intake of children in the study groups was dominated by bottle-feeding. Table 23 shows the artificial milk intake of children in the study groups. There was no significant differences between the study groups and the control group D in the starting age of powdered milk and fresh milk intake.

4.2.4.8 Present diarrhoea episode:

Table 24 shows the duration of diarrhoea in children at the inclusion in the study. There was no significant difference between the study groups and the control group in the mean duration of the present diarrhoea.

4.2.4.9 Fluid intake:

Table 25 shows the mean values of characters on inclusion in the different study groups. There was significant differences in the duration of breast milk and the starting age of fresh milk intake between children of group C and the control group.

Table 26 illustrates the stool character of the study group at inclusion in the study. No significant difference existed between the study groups and the control group D. Eleven children experienced bloody diarrhoea in the study.

Table 27 shows the number of motions per day in the study groups at inclusion in the study. Most of the children in the study had 4-6 motions per day. No significant difference between the study groups and the control group.

Fig.9 Artificial milk intake of children in the study groups

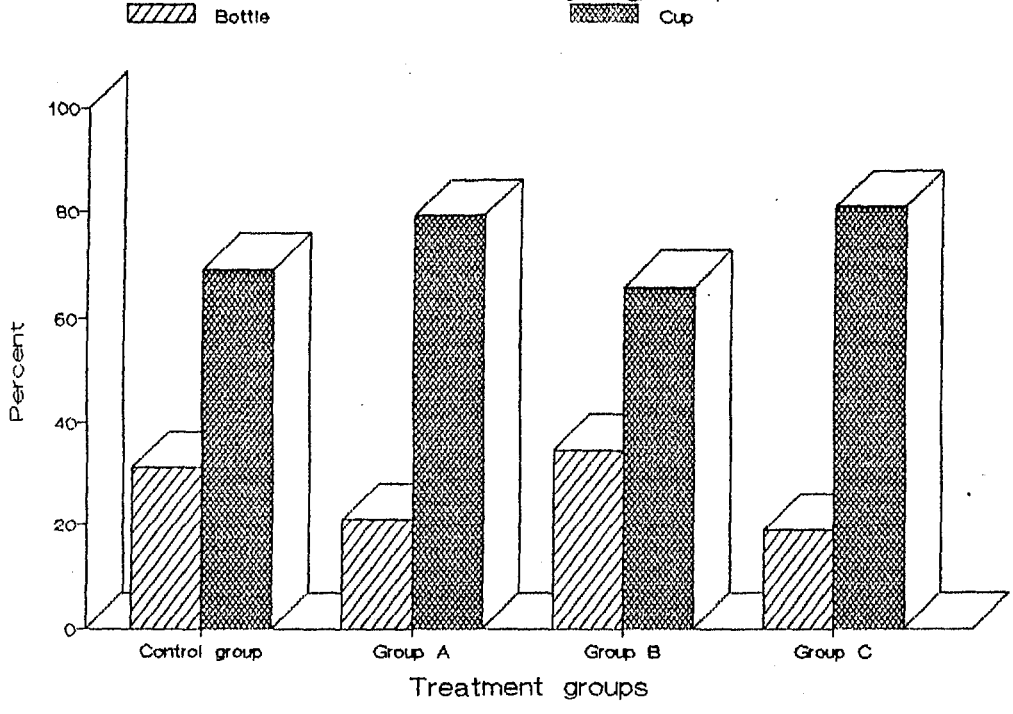


Table 23 Artificial milk intake of children in the study groups

| Artificial milk | A No (%) | B No (%) | C No (%) | D No (%) |
|---|---|---|---|---|
| Fresh milk intake | 27(84) | 26(74) | 20(80) | 12(57) |
| Starting age of intake (month) mean ± SD | 6.84(3.28) ** | 7.35(3.39) ** | 5.64(2.28) ** | 6.36(2.87 |
| Powdered milk intake | 2(6) | 4(11) | 10(40) | 5(24) |
| Starting age of intake (months) mean ± SD | - | 5.0(0.508) ** | 5.83(3.37) ** | 6.43(2.76 |

Table 24. Duration of diarrhoea in children at inclusion in the study

| Duration (hours) | A No (%) | B No (%) | C No (%) | D No (%) |
|---|---|---|---|---|
| 6 - 24 | 3(10) | 1(3) | - | 1(5) |
| 24 - 48 | 6(20) | 4(13) | 1(4) | 2(11) |
| 48 - 72 | 6(2 | 14(45) | 9(36) | 5(26) |
| 72 - 96 | 5(15) | 7(22) | 7(28) | 5(26) |
| 96 - 120 | 4(13) | - | 2(8) | 2(11) |
| 120 - 144 | 1(3) | - | - | 2(11) |
| 144 - 168 | - | 2(7) | - | - |
| 168 - 262 | 3(10) | 2(7) | 3(12) | 2(11) |
| > 262 | 2(3) | 1(3) | 2(8) | - |
| Mean duration (± SD) | 97.23 135.66 | 80.71 88.32 | 126.0 15.2 | 77.37 51.1 |

Table 25. Mean values of characters on inclusion in the different study groups

| Characters | D (control) Mean ± SD | A | B | C |
|---|---|---|---|---|
| Duration of breast milk (months) | 12.43±4.31 | 10.81±4.24 ** | 11.24±5.37 ** | 11.2±5.11 * |
| Starting age of fresh milk (months) | 6.36±2.87 | 6.84±3.28 ** | 7.35±3.39 ** | 5.64±2.28 * |
| Starting age of powdered milk (months) | 6.43±2.76 | - ** | 5.0 - ** | 5.83±3.27 ** |

Table 26. *Stool character of the study group at inclusion in the study.*

| Stool character | A n = 32 No (%) | B n = 35 No (%) | C n = 25 No (%) | D n = 21 No (%) |
|---|---|---|---|---|
| Watery | 13(12) | 30(27) | 15(13) | 16(14) |
| Loose | 6(5) | | 5(4) | 1(1) |
| Mucoid | 4(4) | 2(2) | 2(2) | 2(2) |
| Bloody | 8(7) | | 1(1) | 1(1) |
| Water + blood | | | 1(1) | |
| Loose + mucoid | 1(1) | 3(3) | 1(1) | 1(1) |
| $X^2$ | ** | ** | ** | ** |

4.2.4.10 Acceptability of Baobab oral rehydration solutions:

The acceptabilty of the rehydration solutions is illustrated in Tables 28 and 29; Fig. 10 and Fig. 11. All the rehydration solutions were accepted by mothers as shown in Fig. 11. Figure 10 illustrates better acceptability of the baobab solutions by children. A highly significant difference ($P \leq 0.01$) existed between the acceptability of children to the baobab solutions and the standard WHO/ORS, while no significant difference existed in mothers acceptability of baobab rehydration solutions and the standard ORS as shown in Table 29. Also all the studied mothers from different areas of origin in Sudan accepted baobab as shown in Table 28. There was no significant difference between the rehydration solutions and the control solution.

4.3 Management of Diarrhoea by Baobab Home Oral Rehydration Solution:

Tables 30, 31, 32 and 33 illustrate the description of diarrhoeal stool of children taking home rehydration solutions. Almost all the children who took solution A recovered after two days. Those who took solution B recovered after three days of administration of the rehydration solution, while the cumulative recovery rate in 3 days was 96% in children of solution C and 86% in children adminstered the control solution. Children with bloody diarrhoea were completely recovered after one day of adminstration of

Number of motions/day in the study groups at inclusion in the study

| A<br>No (%) | B<br>No (%) | C<br>No (%) | D<br>No (%) |
|---|---|---|---|
| 9(8) | 4(4) | 9(8) | 3(3) |
| 19(17) | 25(22) | 15(13) | 13(12) |
| 2(2) | 6(5) | - | 2(2) |
| 2(2) | - | 1(1) | 1(1) |
| ** | ** | ** | |

Table 28 Acceptability of rehydration solutions in relation to the area of origin of children's mothers.

| Tribe (Sudan) | Solution A n=32 | | | Solution B n=35 | | | Solution C n=25 | | | Solution D n=21 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Yes | No | Moder. | Yes | No | Moder. | Yes | No | Moder. | Yes | No | Moder. |
| South | 3 | - | - | 3 | - | - | 16 | - | - | 13 | - | - |
| North | 69 | - | - | 57 | - | 3 | 37 | - | - | 54 | - | 2 |
| West | 25 | - | 3 | 30 | - | 7 | 42 | - | - | 14 | - | 13 |
| East | | | | | | | 5 | - | - | | | |
| $\chi^2$ | ** | | ** | ** | | ** | ** | | | | | |

Table 29 Acceptability of the rehydration solution by study groups and their mothers.

| Acceptability | A n = 32 No (%) | B n = 35 No (%) | C n = 25 No (%) |
|---|---|---|---|
| Children acceptance | | | |
| Yes | 32(100) | 31(93) | 24(100) |
| No | - | - | - |
| Moderate | - | 2(6) | - |
| $X^2$ | * | * | * |
| Mothers acceptance | | | |
| Yes | 31(97) | 29(91) | 23(100) |
| No | - | - | - |
| Moderate | 1(3) | 3(9) | - |
| $X^2$ | ** | ** | ** |

Fig. 10 Acceptability of rehydration solutions by children with diarrhoea

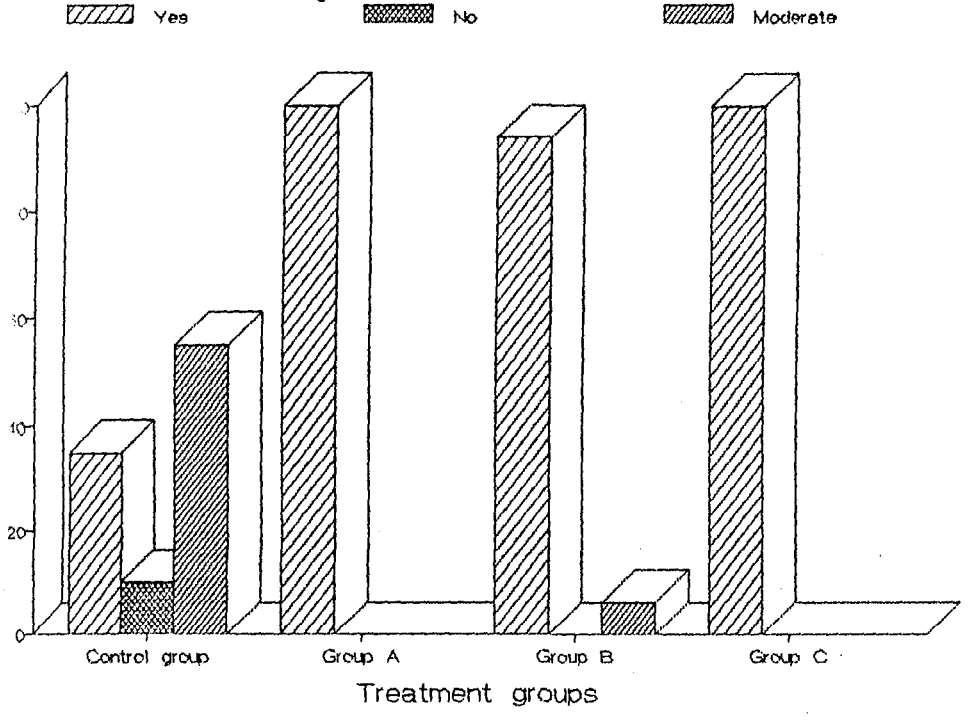
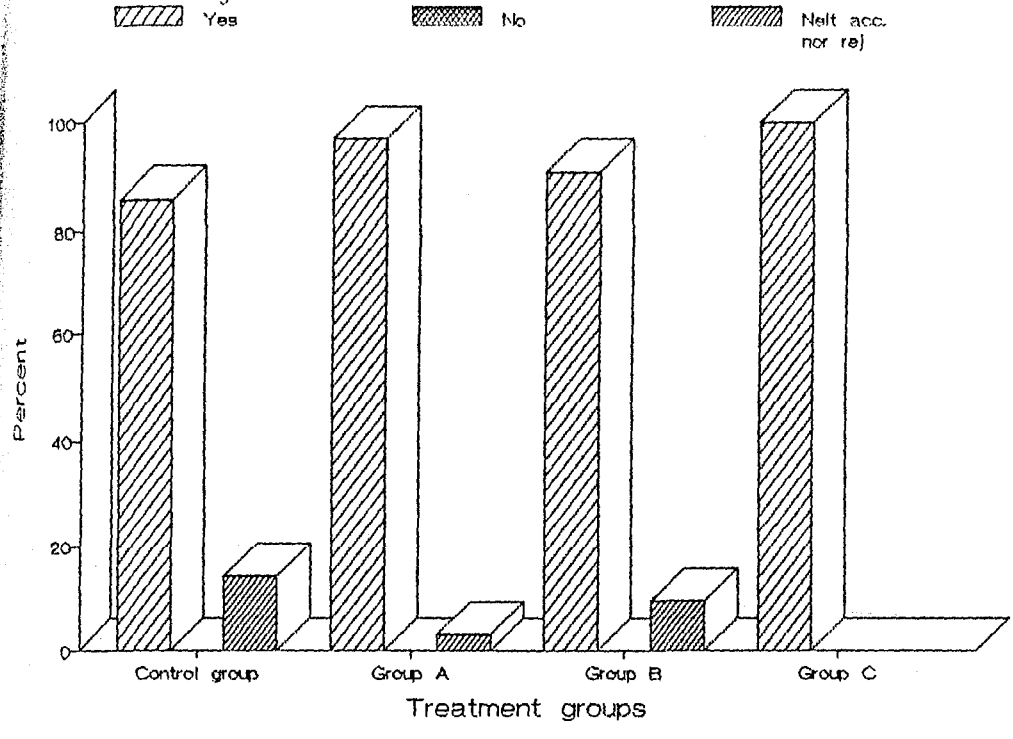


Fig. 11 Acceptability of rehydration sol
ution by mothers children with diarrhoea



Description of diarrhoeal stool of children taking baobab home rehydration solution A.

| ›al ›r | Prior to study No (%) | Day 1 No (%) | Day 2 No (%) | Day 3 No (%) |
|---|---|---|---|---|
| | 13(41) | | | |
| | 6(19) | 10(31) | | |
| | 4(13) | 2(6) | | |
| | 8(25) | | | |
| | 1(3) | 1(3) | | |
| | | 19(59) | 13(41) | |
| | | ** | * | * |
| ncy | | ** | * | * |
| | 9(28) | 31(97) | 7(22) | |
| | 19(59) | 1(3) | 1(3) | |
| | 2(6) | | | |
| | 2(6) | | | |
| ed | | | | |

Table 31 Description of diarrhoeal stool of children taking solution B rehydration baobab home solution.

| Diarrhoeal stool character | Prior to study No (%) | Day 1 No (%) | Day 2 No (%) | Day 3 No (%) |
|---|---|---|---|---|
| Watery | 30(86) | 3(9) | | |
| Loose | | 25(71) | 8(23) | |
| Mucoid | | | | |
| Water, Mucoid | 2(6) | | | |
| Blood + mucoid | 3(9) | | | |
| Normal | | 7(20) | 20(57) | 8(23) |
| $X^2$ | | * | * | * |
| Frequency | | 25(71) | 9(26) | |
| < 4 | 4(11) | 25 (71) | 9 (26) | |
| 4 - 6 | 25(71) | | | |
| 6 - 8 | 6(17) | | | |
| Stopped | | | | |

32 Description of diarrhoeal stool of children taking solution C rehydration baobab home solution in combination with ORS.

| rhoeal l acter | Prior to study No (%) | Day 1 No (%) | Day 2 No (%) | Day 3 No (%) |
|---|---|---|---|---|
| ry | 15(60) | 2(8) | 1(4) | 1(4) |
| se | 5(20) | 12(48) | 2(8) | |
| id | 2(8) | 3(12) | 1(4) | |
| dy | 1(4) | 1(4) | | |
| er + id | 1(4) | | | |
| se + id | 1(4) | | | |
| rmal | | 7(28) | 14(66) | 3(10) |
| | | ~~7(28)~~ * | 14(66) * | 3(10) ** |
| equency | | | | |
| 4 | 9(36) | 15(60) | 9(36) | 3(12) |
| - 6 | 15(60) | 4(10) | | |
| 8 | 1(4) | | | |
| topped | | | | |

ble 33 Description of diarrhoeal stool of children taking solution D ORS (control).

| iarrhoeal tool haracter | Prior to study No (%) | Day 1 No (%) | Day 2 No (%) | Day 3 No (%) |
|---|---|---|---|---|
| atery | 16(76) | 1(5) | 15(21) | 3(14) |
| oose | 1(5) | 17(80) | 1(5) | |
| ucoid | 2(10) | 1(5) | | |
| loody | 1(5) | 1(5) | | |
| ater + ucoid | 1(5) | | | |
| oose + ucoid | 1(4) | | | |
| Normal | | 1(5) | 4(19) | 13(62) |
| $x^2$ | | | | |
| Frequency | | | | |
| < 4 | 5(24) | 14(67) | 14(67) | 5(24) |
| 4 - 6 | 13(62) | 4(19) | 3(14) | |
| > 8 | 2(10) | 3(14) | | |
| 6 - 8 | 1(5) | | | |
| Stopped | | | 4(19) | 12(57) |

solution A or solution B. Figure 12 and Fig. 13 describes e diarrhoeal stools one day and two days after the hydration solutions were given to the study groups. The gures show that the baobab solution had distinct management fect on children with diarrhoea.

Fig. 12 Description of the stool one day after rehydration solutions were given

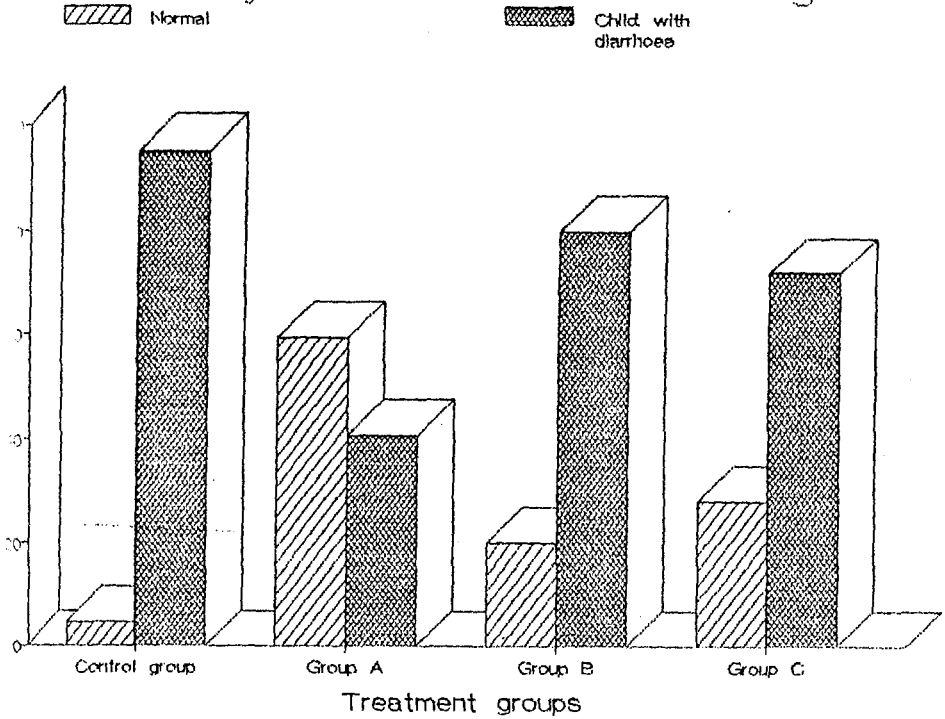
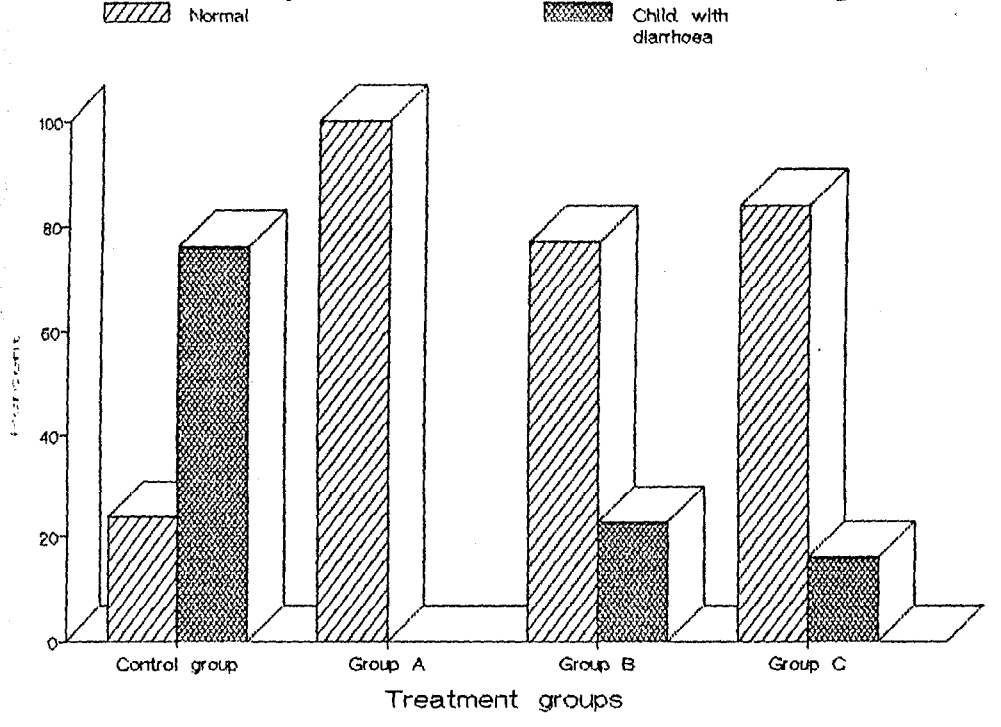


Fig.13 Description of the stool two days after rehydration solutions were given



# CHAPTER V

# DISCUSSION

## ntroduction:

The study was carried out to evaluate the efficacy and ›tability of home available baobab solution for management .arrhoea in children and prevention of dehydration. Baobab tion was compared to the standard ORS and was assessed for mmendation as a home made solution for management of dren with diarrhoea to the National Diarrhoeal Disease rol Programs, Sudan, since baobab (Adansonia digitata) t pulp is accepted in traditional medicine for treatment iarrhoea and dysentery[115]. The greatest emphasis should be n to replacement of diarrhoea as early as possible in the ıess before the appearance of dehydration. Thus, the .lability and acceptability of the baobab solution and the ntial value of the baobab biochemically, in addition to clinical data on the studied children, documented both the entific basis and the efficacy of the applied solutions as ventive measures against dehydration and shortened the rrhoeal duration.

Although the World Health Organization (WHO) ORT formula proved to be effective and safe in the treatment of lions of cases throughout the world, it provides very few ories (8 kcal/100 ml) at a time when increased energy ırces are badly needed.

The biochemical studies and the clinical data on patients displayed possible benefits in the form of:

1- Increased and faster fluid and electrolyte absorption.

2- Increased nutrients absorption providing both energy and amino acids.

3- Decreased stool volume.

4- Faster recovery due to:

1- Shorter cell renewal time as a result of readily available basic nutrients for cell metabolism.

2- Better absorption of ORT.

3- Better digestion of diet in recovery due to continued enzyme induction.

A working group in the study and treatment of diarrhoea involving Jon Rohde et al. (1981) suggested a local source of high potassium food to encourage their use during both home rehydration and convalescence[114].

5.2 Biochemical studies:

Nutrients can be divided into four groups[113]:

1- Energy-yielding nutrients.

2- Essential inorganic elements.

3- Vitamins.

4- Fibre.

The studied baobab home rehydration solution can be evaluated as a more efficacious and nutrients dense rehydration solution documented by the following biochemical

results.

5.2.1 Energy Yielding Nutrients:

The biochemical studies showed that baobab fruit pulp contained 2.6% protein, 0.2% fat, 2.61% fructose, 2.9% glucose, 12.8% sucrose. Previous studies on the chemical composition of baobab showed higher result in total sugars (23.2%) and similar protein and fat contents[134].

The calculated available energy of the studied rehydration baobab solutions A and B were 2.25 times the energy available from the control solution. Solution C available energy was 1.3 times the energy available from the control.

The energy available from 100g rice is 337 kcal and that from milled sorghum (Durra) is 330 kcal[202]. Comparing the available energy of baobab solution per 100 ml (18.3 Kcal) with the available energy from solution of 50g rice (18.9 Kcal/100 ml) or 50g sorghum (16.5 Kcal/100 ml), it can be considered that baobab solution have similar available energy as sorghum and rice oral rehydration solutions.

The absence of lactose in the studied baobab fruit is normal, since lactose is a unique carbohydrate source found only in mammalian milk and in one group of plants, the sapotaceae[139].

5.2.2 Essential Inorganic Elements:

Potassium:

Results obtained showed that baobab is a rich source of potassium (450 ppm). A study on the treatment of diarrhoea suggested a local source of high potassium food to encourage their use during both home rehydration and convalescence[114].

Potassium losses are high specially in infant diarrhoea. Baobab solution can be considered as an optimal rehydration fluid. Solution A and solution B contained 21 meq/litre potassium, while solution D contained 20 meq/litre. As hypokalemia is associated with apathy, decreased appetite, a dynamic ileus and general disturbance of smooth muscle system specially in the early rehydration stage, early replacement of potassium is an important issue for electrolyte and nutritional therapy[114]. Important evidence showed that the anorexia of diarrhoea is responsible for a considerable part to the nutrients deficiency in diarrhoea[114].

Calcium:

The baobab fruit contained appreciable amount of Ca (670 ppm). A previous study in Sudan recorded 6550 ppm of calcium in the baobab fruit pulp[134]. A study examined the calcium intakes of rural Gambian women during pregnancy discovered baobab fruit as unusual source of Ca[140]. Similar results were reported in Nigeria[130].

Iron:

In this study the amount of Fe was 5.3 mg/100g which is thirteen times higher than the concentration in peeled orange (0.4 mg/100g). High value of Fe was reported (8.6 mg/100g) in baobab fruit pulp in Sudan[134]. Baobab is an inexpensive source of Fe, hence Fe could be provided to children of low income families, taking into consideration the level of vitamin C (335 mg/100g) which helps in its absorption.

Zinc:

The study showed that the baobab fruit contained Zn (10 ppm). Recent studies on prevention of diarrhoea in children living in developing countries, suggested dietary supplementation with zinc and iron[74]. Shrimpton (1993) mentioned that the duration of diarrhoea may be reduced by zinc supplement, and concluded that zinc may not be the only essential mineral but the "first" limiting. This means that it is the critical limiting factor in the diet[141]. In New Delhi (India) a study was carried out to evaluate the effect of oral zinc supplementation after completion of rehydration. The result showed that the diarrhoeal duration and frequency in the zinc supplemented group were lower, but the differences were not statistically significant. It was suggested that the possible antidiarrhoeal effect of zinc merits further study[142].

Others:

The baobab fruit pulp under study also contains Cu (15

ppm), Cr (297 ppm), Ti (865 ppm), Mn (67 ppm), Ni (55 ppm) and Se (10 ppm). The patients receiving parenteral nutritional support should be given the trace elements zinc and copper, while patients with diarrhoea will require additional zinc to replace faecal losses. Additional trace elements: chromium, manganese and selenium are provided to patients receiving long term parenteral nutrition[144].

The presence of lead (6 ppm) in the studied sample is normal, since the element is being introduced continuously to the biosphere. The study of Lehnert et al. on German food showed that practically no lead free food exists[146]. Harley reported that in American population, the diet contributed the major portion of lead intake[147]. In India, a study of the lead content of various foods consumed concluded that cereals and pulses were found to contain higher amounts of lead than other food groups.

We concluded that the unusual high content of minerals (K, Ca, Ti and Cr) in addition to the other elements (ash content of the fruit pulp is 5.7%) may explain the enhanced management of diarrhoea.

5.2.3 Vitamins content:

The ascorbic acid content of the baobab fruit pulp is 335 mg/100g. Previous studies also showed that baobab fruit pulp in a rich source of vitamin C (337 mg/100g)[130,134]. The pulp has been reported to be a valuable source of thiamine and

riboflavin but we concluded that none was found in this study.

The results showed that the nicotinic acid content was 50 mg/100g and vitamin $B_6$ 10 mg/100g. Pellagra is usually associated with a defficiency of not only niacin but also trytophan and pyridoxine[151]. We conclude that the baobab fruit pulp contains both the vitamins nicotinic acid and pyridoxine.

5.2.4 Fibre:

Previous study on baobab fruit pulp showed that it contained 5.7% crude fibre and 56.2% pectin which is characterized by its low degree of esterification[134]. Several studies investigated the importance of pectin in nutrition. A daily intake of 30g fibre was recommended, half of which from coarse wheat bran[152]. An in vitro study illustrated the binding of mineral elements to low and high methoxyl pectin. The results of the study showed that there was considerable binding of minerals to the low methoxylated pectin[153]. A study on intestinal zinc transfer of rats given diets containing different amounts and types of dietary fibre, showed that the highest rate of transfer was by colonic tissue from pectin-fed rats[154]. Another study showed the positive effects of pectin on the gut microflora[155].

A study tested the efficacy of smectite, a clay mineral, which is a natural adsorbant clay capable of adsorbing viruses, bacteria, and other intestinal irritants. It claimed that smectite possessed beneficial antidiarrhoeal properties.

The study suggested a beneficial effect of smectite in shortening the duration of diarrhoea and reducing the frequency of liquid stool in children rehydrated with ORS[156]. Another study concluded that smectite shortened the coarse of acute secretory diarrhoea in Thai infants[157]. All these findings on smectite may be comparable to the baobab rehydration solution for its minerals and pectin content.

The low methoxyl pectin in the presence of cations forms salt linkages between the free carboxyl groups and the cations. Thus, the low methoxyl pectin may bind the bacterial toxin. This might explain the antidiarrhoeal effect of baobab fruit pulp.

The results of the biochemical studies showed that baobab fruit pulp contains sugar, protein, low methoxyl pectin in addition to the minerals and vitamins, that is, more co-transporting molecules can be made available with little or no osmotic penalty.

5.2.5 Tannins:

The tannins content of baobab fruit pulp was 0.5%. Previous studies showed that infants aged 3 - 21 months with acute diarrhoea of bacterial and viral origin, treated with ORS and received for up to 6 days a tannin rich "carbo-pod powder" and dietary fibre, accepted and tolerated the test substance. It normalized defecation and body temperature. In addition, weight and cessation of vomiting were reached more

quickly by the patients who received the test substance[145].

5.2.6 Osmolality of baobab rehydration solutions:

Solution A was hypotonic with osmolality of 170 mosmol/l, solution B was a normal solution (282.5 mosmol/l). Solution C was hypertonic (337.5 mosmol/l). Solution D was hypertonic (311 mosml/l).

Several clinical trials studied ORT with different osmolality. It was found that many diverse formulations with different concentrations of sodium and glycidic components were more effective in treatment of acute infantile diarrhoea[44].

Solution A was hypoosmolar (170 mosmol/l). A previous study showed that low osmolality was of primary importance in mediating the increased water absorption from cereal-based ORS[158]. Another study concluded that solutions containing polymeric glucose as substrate can significantly reduce stool output, duration of diarrhoea and total oral rehydration solution requirement[159]. In Bangladesh a clinical trial with children suffering from acute diarrhoea suggested that staple-based or food-based ORS was the optimal treatment of diarrhoea[75]. A study in Bangladesh showed significantly greater net water absorption from maltodextrin electrolyte solution compared to WHO-ORS[162]. Several other studies assessed the efficacy of ORS solutions with different osmolality. In Finland a study showed that hypotonic ORS (224 mosmol/l) had

clinical advantages over the standard ORS (304 mosmol/1) for the treatment of dehydration due to acute diarrhoea[47]. A comparison of two oral rehydration solutions with different sugar contents and osmolality (326 mosmol/1 and 240 mosmol/1) showed that there was no significant difference between the two ORS[160].

Another study compared the efficacy and safety of two ORS solutions (one solution had sodium 60 mmol/1 and osmolality of 240 mosmol/1 and the other solution had sodium 26 mmol/1 and osmolality of 340 mosmol/1) in children with mild to moderate dehydration. The results showed that no adverse drug reactions occurred and none was considered a treatment failure[45]. An investigation concluded that oral rehydration therapy was safe and efficacious in the management of dehydration in acute diarrhoea and that lower osmolar rehydration solution had clinically marginal advantages[161]. In England a study showed that citrate ORS was clinically advantageous in a hypotonic ORS, but a hypotonic formula without a base precursor was also effective[163].

5.3 Clinical Data on Patients:

It is the first randomized clinical trial in Sudan to assess the efficacy of a traditional baobab solution (fruit pulp extract) and baobab-based solution in the management of diarrhoea with no or mild dehydration. The studied children, aged 6 - 60 months, were allocated to four groups: group A (32

patients) was managed with baobab solution sweetened with household sugar, group B (35 patients) was managed with baobab solution to which household sugar and table salt were added, group C (25 patients) was treated with baobab-based ORS solution and the control D group (21 patients) took the standard ORS. The period for evaluating the efficacy of the solutions was three successive days.

Nutritional status of patients included in the study was normal in most children, only few children with mild degree of malnutrition (under weight) and only one child was over weight. The reason was the exclusion of severly malnouriched children with diarrhoea, because most of the oral rehydration solutions have been tested in well nourished children[96]. Therefore children in the 4 groups were comparable in mean age and weight.

5.3.1 Age group incidence of diarrhoeal diseases:

It was found that the highest incidence of diarrhoeal diseases was among the 7 - 12 months age group of the studied children.

A previous study conducted at the Children Emergency Hospital Khartoum showed that the peak incidence of diarrhoeal diseases was in the 6-11 months age group[87] which is within the range of the international norm. In Addis Ababa (1981) children under 2 years of age were found to be most susceptible to diarrhoeal diseases[164]. Sudan Demographic Health

Survey in 1990 estimated that the high prevalence of diarrhoeal diseases was among children of 2-23 months of age.

In another study in rural Alwar (India) among 875 children with diarrhoea under 5 years of age, it was found that the incidence decreased with increase of age and was significantly more in children of illiterate mothers, of poor socio-economic conditions[26].

5.3.2 Socio-economic background of families:

5.3.2.1 Education:

The education of the children parents was as follow: only 8% of the mothers and 2.3% of the fathers were illiterate. 23.9% of mothers and 15.9% of fathers received primary education (primary schooling). Most of the mothers (62.5%) and fathers (64.7%) received secondary education (intermediate or secondary schooling), 17% of fathers and 5.7% of mothers received tertiary education (university graduates). The good educational background of the sample explains why all the parents accepted the idea of participation in the study for three successive days. Incentives were needed only for group D (the ORS group) to encourage the follow up.

5.3.2.2 Sanitory environment:

The study showed that 80.5% of families had safe water inside the house, that is water obtained either from tap (76.1%) or from a well (4.4%). Flush latrines were used by 22.9% of the families, and 63.0% used pit latrines, while

13.8% of the families had no latrine. A previous study at the Children Emergency Hospital Khartoum (1991), on 96 families of children reported 57.3% had safe water supply and 83.2% of the families had pit latrines, while flush latrines were used by only three families[87]. The sample studied lived in a better sanitory condition. In this study although 86.5% of families used safe water, the mothers were advised to prepare the baobab solutions with preboiled water to ensure the sterility of the fluid. The reason that 13.8% of the families had no latrine was because their fathers were labourers in the new extensions of the city and the families were resident in the new buildings without services. This was also the reason for the relatively high percentage of flush latrine.

5.3.3 Diarrhoea history of the sample:

In the study 56.6% of the children had no diarrhoea before which reflected the good socio-economic status of the families, good beliefs and practices. Those who had diarrhoea twice before were 14.2% and only 2 children had diarrhoeal more than 5 episodes before. The mean number of past diarrhoeal episodes were two. Children with past history of diarrhoeal episodes (78.2%) had been affected during the period of breast-feeding which was for about one year.

5.3.4 Fluid intake:

Children in the different groups in the study were comparable in the duration of breast-feeding, starting age of

artificial milk, duration of present diarrhoea, weight of children and past diarrhoeal episodes. This ensured the reality of the study, that is, groups with more or less the same historical background were compared.

It was stated that in developing countries formula feeding is associated with infection, malnutrition, increased mortality and decreased birth spacing and that breast-feeding is the physiological mode of feeding, hence, reasonably to be regarded as ideal[139]. Another study concluded that breast-feeding reduced energy deficit resulting from diarrhoea and suggested exclusive breast-feeding through at least the first 4 months of infant age and to continue partial breast-feeding until 24 months of age, that is during the infant's susceptibility to diarrhoeal attack[165,166]. In rural Ethiopia it was reported that 99% of mothers had breast-fed their last child, more than 25% weaned only after the seventh month of age[167].

In 31% of the studied children, breast-feeding was stopped at less than 4 months of age. This percentage is very high taking into consideration the importance of breast-feeding during the early four months of life. This may be related to past diarrhoeal attacks during which the infant lost appetite and refused breast-feeding as claimed by some of the mothers. A previous study in the urban and rural communities in Sudan, showed that 67% of the mothers stopped

breast- feeding during diarrhoea[203]. In contrast, another household survey in Khartoum North (Sudan) showed that 95% of the mothers continued to breast-feed during diarrhoea[7]. A study conducted at the Children Emergency Hospital Khartoum showed that breast-feeding was practiced by 65.6% of mothers[87]. Another study found that young infants who were not breast-fed had 25 times greater risk of dying of diarrhoea than those who were exclusively breast-fed. It was also found that exclusively breast-fed infants have a reduced risk of diarrhoea morbidity. Thus, exclusive breast-feeding must be extended at least 4-6 months. The addition of early food supplementation to infants under prevailing environmental conditions in developing countries increased diarrhoeal attack[168].

An interesting finding was that cup-intake of artificial milk was dominant over bottle-intake among all the studied children in the different groups. This may be due to the awareness of the mothers about the complications of bottle feeding or to economic reasons (unavailability of bottle or its high price). Studies carried out in developed countries before the introduction of antibiotics, and in developing countries showed markedly higher morbidity and mortality rates from infections in bottle-fed infants compared with infants fed on breast milk[139].

5.3.5 Management of diarrhoea:

In this study it was found that 85.8% of the studied children were treated medically by the health service staff during their past experiences of diarrhoeal diseases, 4.4% were treated by private practitioners, and 9.7% were not taken for treatment in past episodes. In north east Brazil a result of a survey of 6524 children less than 5 years old showed that 66.1% of the children were not taken for treatment, while governmental health services were used by 14%, private doctors by 1% and traditional healers by 24%[170]. In Nicaragua the result from a study of household management of childhood diarrhoea of 109 mothers carried out during 1987-1988, showed that although mothers knew about dehydration and ORS, they relied on self-prescribed pharmaceuticals and home remedies, while ORS was associated with clinic attendance[171].

In Haryana (India) rural mothers attributed the childhood diarrhoea to eruption of teeth (67.59%), eating of mud (51.85%), worm infestation (47.22%), change of climate (35.18%) poor personnel hygiene (34.25%), changes in diet (25.92%)[176].

A study in rural Alwar (India) showed that 50% of episodes of diarrhoea were treated with antibiotics, only one child was given ORS. It was concluded that intensive health education campaigns were necessary for mothers and health professionals[26].

Another study in the rural communities of two villages in Sudan (1988) showed that less than 40% of mothers could identify symptoms and signs of "some dehydration" and the need for consultation. Only 10% could relate danger signs to severe dehydration. The majority of mothers attributed diarrhoea to teething, milk of pregnant women, hot food and salty water[11].

The studied sample was educated, and this may explain the awareness of families for the need of hospital treatment compared to previous studies in north east Brazil, Nicaragua, India and Sudan.

5.3.6 Past admission to hospitals:

In this study 28.6% of all the studied children had been admitted to hospital before. The main cause of admission was respiratory diseases (67.9%). Only 2.0% of the studied children were admitted to hospital due to measles, which reflected the immunization coverage of the studied children.

5.3.7 Traditional management of past diarrhoeal episodes:

Traditional management of diarrhoea was widely used (46.9%). Fumigation (smoke bath) was the common practice (69%) or fumigation in combination with removal of teeth buds, cautry, or blood letting. No studies were carried out to assess its efficacy. Fumigation of dehydrated children during episodes of diarrhoea is dangerous because it worsens the condition of the child by the induction of sweating. At the beginning of diarrhoea, it may induce excess fluid intake,

specially of baobab solution which has a distinct management effect on child with diarrhoea.

A previous study in Sudan (1988) showed that both literate and illiterate mothers practiced fumigation (50%) cautery and removal of teeth buds (10%, 45%), withholding of breast-feeding (30%, 45%) while the use of drugs was practiced by 30.5% and 20% respectively[11].

The study done at the Children Emergency Hospital, Khartoum demonstrated that fumigation was among the most frequently used traditional practice (69%), followed by removal of tooth bud (46%), and the use of boiled herbs (39%). Other practices that include cautery, blood-letting were used less frequently[87].

Traditional management of diarrhoea can play a role in management of malnourished children with diarrhoea. A study in Madagascar assessed the efficacy of rice which is a traditional management for diarrhoea in that country[96]. A formula based on fermented milk together with oral rehydration can be used to treat malnourished children with acute diarrhoea and sugar intolerance[72]. Traditional remedies are also used in other countries e.g Somalia[173].

Traditional practices need extensive research to assess their efficacy. Complications that result from the very septic condition, like local infections, septicaemia, severe hemorrhage or tetanus had been reported and death may occur[172].

5.3.8 Special diarrhoeal food:

The scientific correction of the physiologic changes induced by diarrhoea is as follows: For acute severe diarrhoea food should be withheld for the first 24 hours or restricted to luke-worm clear liquid. A physiologic glucose and salt solution given to replace fluid and electrolyte losses, and frequent small soft feeding is added as tolerated. Milk and milk products are the last foods to be added (lactose deficiency is temporary present after an insult to the small intestine). Patients convalescing from acute diarrhoea should avoid raw vegetables and fruits, fried foods, barn, whole grain cereals, preserved syrups, candies, pickles, spices and coffee. Nutritious foods, preferably all cooked, in small frequent meals, is usually well tolerated[169].

In this study special diarrhoeal food intake was also revised during past diarrhoeal episodes. It was found that 77% of the studied children had taken special diarrhoeal foods whereas only 23% did not.

The idea of management of diarrhoea with special foods is present in the cohort of mothers, thus the inclusion of baobab solution for management of diarrhoea and prevention of dehydration is very easily accepted, supported by beliefs and tradition.

In this study the most popular home available fluid for management of children with diarrhoea was custard water. 27.6%

of the studied children had taken custard water and 21.9% had taken rice and custard solution. The second popular home fluid was rice, 18.4% had taken rice alone and 21.9% had taken it with custard. "Nasha" (which is a thin pap made from sorghum flour, its constituent mainly starch) was the third popular home fluid taken by 16% of the studied children. Herbal treatment was experienced by only one child.

Traditional healers in Uganda presented traditional methods in management of diarrhoeal diseases. They used herbs and water as the main sorbant for herbal preparation, 26.4% of healers considered fluid supplement as mandatory and 70.5% advised patients to take as much fluid as possible. Only 3.1% of healers either limited or did not advice fluid intake[179]. A study in Uganda during 1987 among mothers of children less than 5 years old, concluded that herbal treatment for diarrhoea was a widespread practice and a study to evaluate its usefulness was recommended[174]. In Mexico 147 mothers interviewed revealed that the majority (90%) gave herbal tea to their children with diarrhoea, followed by rice-based beverage (77%) and only 18% mentioned the use of oral rehydration salts packages. Sixty three percent avoided certain foods, 25% withheld all foods, usually for more than 24 hours[175]. In another study in rural Mexico, it was found that herbal tea and rice-based beverages were most commonly used and that during diarrhoea mothers modified the usual diet

fed to the child rather than to withhold foods[24].

In our study the most common practice for management of diarrhoea was special foods and fumigation whereas in Uganda herbal management was a common practice. In Mexico, herbal tea and rice-based beverages were the most common practice.

Management of diarrhoea with special foods is also practiced in Pakistan. The efficacy of a traditional diet in early feeding of male children 9-40 months of age with diarrhoea with moderate to severe dehydration was investigated. "Khitchri" is a traditional legume-based weaning diet composed of rice and lentils cooked with cotton seed oil. Children were allocated randomly to two groups, group A received "Khitchri" and half strength cow's milk formula freely after initial rehydration period of 24 hours with WHO/ORS, while group B received "Khitchri" and the half strength formula after initial rehydration period of 4-6 hours. The mean period of evaluation was 3 days. It was concluded that early feeding of "Khitchri" and WHO/ORS were as well tolerated as WHO/ORS alone in the first 24 hours of treatment of severe acute diarrhoea in young children[98].

Another study in France suggested that there was no immediate clinical advantage to dilute the milk in the first 24 hours of feeding well nourished children with moderate acute watery diarrhoea, if early feeding is associated with WHO/ORS[177]. In Finland, a study on early home management of

acute diarrhoea before hospitalization revealed that early feeding at home may promote reduction of intestinal permeability and hence hasten recovery[178].

In Afghanistan, an interview with the parents of 338 children revealed that 56.3% of the parents gave an increased amount of fluid such as plain water, soup, yoghurt mixed with water or tea during the diarrhoeal attack[180].

All these studies revealed the importance of some traditional diets in management of diarrhoea at the home level. The clinical experiences have shown that with ORT and appropriate dietary therapy, most patients with diarrhoea can be managed effectively thus avoiding the injudicious use of intravenous fluids and the irrational prescription of antibiotics.

The Department of Preventive and Social Medicine in Rohtak (Haryana, India) found that the majority of rural mothers in Haryana (83.33%) believed that ORT alone can not treat diarrhoea. The home remedies tried by mothers were, isabgol husk with curd (30.55%), ghee with tea (28.7%), water boiled with mint leaves (25.92%), local ghutti and unripe mango juice (16.66%)[176]. The International Centre for Diarrhoeal Disease Research in Bangladesh studied the use of energy dense and liquified rice porridge by amylase of germinated wheat in infants 5-12 months age with acute watery diarrhoea after rehydration with ORS. The results indicated

that the intake of liquified porridge was 40% greater than that of the standard viscous porridge[182].

The antidiarrhoeal agents are quite common even in the hands of pediatricians[36]. In Nigeria a total of 247 bacterial isolates were obtained from patients with diarrhoea aged 0-60 months in an Oral Rehydration Therapy Clinic in Ibadan and tested for sensitivity to 11 antibiotics. The results of the study showed that 2.4% of the bacterial isolates were resistant to all the 11 antibiotics used in the test and that most of the others were resistant to several antibiotics. Isolates from the control group also exhibited resistance to several antibiotics. It was concluded that there was a high incidence of multiple-antibiotic resistant isolates within the same environment[181].

5.3.9 Fluid intake:

The pattern of fluid intake by children in our study revealed that 74.2% of the children continued breast-feeding. Those who stopped breast-feeding were 9.3%. That was not their mother's wish but the children refusal to take the breast milk. This behaviour of the children by instinct may have a scientific basis. A study showed that milk and milk products were the last foods to be offered to children with acute diarrhoea because temporary lactose deficiency frequently resulted after an "insult" to the small intestine[169]. The studied children mothers (2.1%) increased breast-feeding.

Children who were taking fresh milk (64.5%) had normal intake.

The biochemical and physiological differences between human and cow's milk are enormous. The two milks have evolved to fulfil completely different functions with respect to bacteria. Human milk is inhibitory to bacterial growth. Substitutes of cow's milk for human milk reduces the anti-infective agents available to the infant and is nutritionally inferior in quality and quantity[183].

Comparing the fluid intake in this study with the finding of a survey done in the rural communities of two villages in Sudan (South west of Omdurman) concluded that one third of literate mothers and one half of illiterate mothers stopped breast-feeding during diarrhoea, 75% of mothers withheld other food during diarrhoea[11].

Another study during 1990 concluded that fluid intake and breast milk intake were restricted in only 15 and 22% respectively. Artificial milk and food intake stopped or restricted in almost 50% of the children with diarrhoea[97].

5.3.10 Diarrhoea status of the sample:

In this study 46% of the children were included after 2 days or less from the start of diarrhoea. Most of the children (87%) had diarrhoea frequency of 4-6 motions/day, 8% had 6-8 motions/day and only 3.5% had more than 8 motions/day, 10.6% of the children were suffering from dysentery.

5.3.11 Acceptability of ORT:

Baobab fruit is available in the Sudan its pulp used as a delicious beverage in the home, and in some hotels and governmental clubs served as a traditional drink. Baobab pulp is commonly chewed or sucked by children and students as a school snack.

In this study almost all the children mothers (93.5%) accepted the idea of management with ORT using baobab solution. Very few neither accepted nor rejected (6.5%) the management with baobab. This indicated that the idea of management with traditional diet is present in the cohort of mothers. The acceptance of the studied children to the administered solutions was as follows: 98% accepted the baobab solution, 2% accepted the solution with some hesitation. Solution A and C were accepted by all the children in the group, while solution B was accepted by 94% and with hesitation by 6% of the children in the group. Solution D (the control WHO/ORS) was accepted by only 35% of the children in the group, but the mothers overcame this problem by giving the solution by the spoon.

Solution A and C were highly accepted by the studied children. There were significant differences between all the studied baobab solutions and the WHO/ORS standard solution. The acceptability of rehydration solutions in relation to the ethnic background of children's mothers was comparable.

5.3.12 Recovery rate:

The recovery from dysentery was complete in all patients taking baobab home rehydration solution after 24 hours of management. Traditionally the baobab solution is used for management of adult and childhood dysentery. In this study the curing effect of baobab on dysentery might be due to microbicidal effect of the pulp which needs further investigation. Another probable reason might be the binding of the toxins to the low methoxylated pectin (56% pectin in baobab) which have a high proportion of free carboxyl groups.

It was found that the recovery rate after 24 hours of management of the studied children with the different home rehydration solutions was as follows: 59% of group A, 20% of group B, 28% of group C and only 5% of group D children recovered after 24 hours of management. The cumulative recovery rate of solution A after 48 hours of management was 100%, solution B 77% and solution C 84%, while the control solution D, was only 24%. After 72 hours of management with the different baobab rehydration solutions, their frequency of diarrhoea (number of motions per day) was exactly equal to that of the standard solution D, that is the recovery measure is secured (the means and the standard deviation of all groups are typically equal). The three solutions A, B and C were good as home-made oral rehydration solutions as the ordinary WHO/ORS solution.

The recovery rate after 24 hours of management with the baobab rehydration solutions showed highly significant differences from the control solution D in case of solutions A ($P \leq 0.00$) and B ($P \leq 0.00$) and significant difference in case of solution C ($P \leq 0.03$).

The recovery rate after 48 hours of management was highly significant in the case of solution A ($P \leq 0.00$), solution B ($P \leq 0.00$) and solution C ($P \leq 0.00$), while the recovery rate after 72 hours of management was significant in group A solution ($P = 0.02$) and group B solution ($P = 0.02$). The difference was not significant in group C solution.

The baobab solution have distinct management of diarrhoea at home at the extent that it exceeds the standard WHO/ORS. Thus the use of baobab solutions for home management of childhood diarrhoea suggested a new relationship between traditional medicine and public health. The management of children with baobab solution at the home level on the onset of diarrhoea is simple, practical, inexpensive, effective, valuably nutritious, safe and hastens recovery. A study in Finland showed that early feeding at home may promote reduction of intestinal permeability and hasten recovery[118]. As persistent diarrhoea is now emerging as a major cause of childhood mortality in tropical developing areas[22] and malnourished children are predisposed to greater incidences of persistent diarrhoea, baobab solution was proven in this study

to be a very effective nutrients rich ORT for management of diarrhoea.

In the developed countries the use of ORS in the treatment of diarrhoea was reviewed. The problems encountered in its use were different from those in developing countries. Oral rehydration solutions (ORS) are relatively little used: in the Netherlands usually clear fluids such as fruit juice and lemonade are given. The addition of sugars, lemonade, milk or fruit juice to make the ORS more acceptable alters their composition significantly. Improving the taste with colorings and flavour's enhancers had not been convincing. Use of ready made solutions is preferred because home preparations result in wide variation in composition[184,185]. The harmful effect may result from erroneous preparation of ORS i.e. the difficulty to measure the right amount of water at home lead to considerable variation in preparations. A study in north east Brazil of 6524 children less than 5 years old showed that only 18% of the mothers prepared the ORT correctly at the household level. The most common error was the use of insufficient water. Of all the rehydration solutions used 39% had a potentially dangerous sodium content[170]. In addition the utilization of ORS at home was limited by its accessibility[4] and its acceptability. Several other studies even in developed countries[184,185,190] stressed that erroneously prepared ORS was life-threatening.

5.3.13 Baobab for management of diarrhoea:

There are biochemical reasons why it is an effective management. Baobab protein (2.6%), acts as a source of nitrogen for the malnourished child. Its constituent amino acids released upon ultraluminal hydrolysis enhances sodium and water absorption, besides its efficacy in restoring lost fluid. Breast and cow's milk are low in copper and infants exclusively fed so occasionally developed hypocupremia, that responded rapidly to copper. The baobab contains the trace element copper. In addition, glucose tolerance is usually impaired in PEM (protein-energy malnutrition) and some cases had shown response to $Cr^{+3}$[186] which is present in baobab in appreciable amounts.

A third important trace element is zinc. A diet for young children rich in milk product of low zinc content had been reported to result in retarded growth, poor appetite and impaired taste. Zinc therapy resulted in catch-cup growth and disappearance of symptoms[186]. The improvement in appetite of children with diarrhoea in this study may be due to the zinc and potassium contents of baobab in addition to its delicious taste.

Rehydration and maintenance of proper fluid and electrolyte balance are the most important aspects of diarrhoea management. The osmotic activity of solution A was 170 mosm/l, solution B 282.5 mosm/l, solution C 337.5 mosmol/l

and solution D 311 mosmol/l. In group A children 59% were completely recovered by the first day of management and the recovery rate was 100% for the second day. The high recovery rate of solution A might be due to its lower osmolality compared to that of blood. This causes water to be absorbed rapidly and hence prevent dehydration.

The baobab solution had no base precursor. A study in Finland[163] showed that a hypotonic solution was effective whether a citrate base was added or not. Another study in St. Bartholomews Hospital (London) showed that hypotonic rice-based ORS or conventional ORS produced more water absorption than hypertonic solutions in in vitro perfusion of normal and secreting rat small intestine[158].

Solution A is hypotonic 170 mosml/l and this may explain the high recovery rate of this solution. Solution A, solution B, and solution C contained baobab. Other ingredients whether NaCl (solution B) or ORS (solution C) had no effect in improving the fruit pulp efficiency in the management of diarrhoea. Thus the efficacy of solution A is related to its lower osmolality compared to the other solutions in the study.

The children included in the study did not suffer from dehydration hence the low content of sodium in solution A was not limiting. Solution A can therefore be taken as desired because the solution had low sodium content hence the child can take as much as can be tolerated even with more

concentrated solution. It was stated that a low sodium solution (50-60 meq/l), while not effective in the severe secretory diarrhoea like cholera, have been used effectively in trials in several countries and may offer a wider margin of safety from electrolyte disorders in the infant age groups[114].

Solution B molar electrolyte concentration was found to be in the range of the recommended WHO/ORS solutions. However, the addition of NaCl did not add to the efficacy of the baobab but raised the osmolality of the solution and gave a salty taste. Solution B can be compared to home-based salt-sugar solution (SSS) which had been established by the WHO Control of Diarrhoeal Diseases Programme for home management of diarrhoea as a cheap, locally available and simple tool to prevent and manage diarrhoeal dehydration at home. The salt-sugar solution (SSS) is prepared in Bangladesh with labon (locally produced sea salt) and gur (unrefined brown sugar)[191]. In north-east Brazil the SSS is prepared at home using the "scoop and pinch" for management of childhood diarrhoea at the household level[170]. In Bali (Indonesia) SSS home management of acute diarrhoea is also practiced[192]. SSS is implemented in South Africa for self-help management of milder diarrhoea[193,194]. In Zimbabwe home treatment of diarrhoea with sugar and salt solution was introduced in 1980 where it reduced the number of dehydrated children presenting for treatment[195]. In Zaire management at home with SSS or ORS was increased from 6% to

53% between 1984 and 1989[196]. The management by SSS is recommended and practiced. Solution B was formulated using home sugar, salt and baobab pulp. Thus solution B can be recommended for management of dehydrated children with diarrhoea if ORS is not available.

Solution C was effective in the management of children with diarrhoea, but its efficacy was less than solution A. Solution C osmolality was higher than the control solution D, because it contained ORS plus the baobab pulp.

For dehydrated children we suggest initial treatment with standard ORS to correct the dehydration, followed by baobab management as soon as hydration is attainable. Solution B is suggested to be used for dehydrated children if ORS is not available. No need for the addition of baobab to the ORS because the valuable vitamin and mineral contents will be affected by the base precursor present in the ORS.

The chemical composition of baobab (K) can be compared with that of sorghum[187,188]. A previous study on sorghum in Sudan for management of Sudanese children with diarrhoea showed that cereal-based ORS solutions shortened the duration of diarrhoea and reduced both the stool volume and the frequency of diarrhoea and vomiting. These effects were more marked with sorghum-based ORS than with rice-based ORS[189]. Rohde et al. suggested local sources of high potassium for home rehydration and convalescence, and the identification of the specific

effect of low body potassium on appetite[114]. Both baobab and sorghum are high potassium sources.

This is the first reported study on the positive use of a fruit (baobab) for management of diarrhoea at the home level. Negative results were attained with coconut milk in Ghana because it can not be used for rehydration due to its glucose and electrolyte composition[197,198].

Since most diarrhoeal attacks are self limiting within a few days, unless diarrhoea and vomiting are severe and treatment is not available death occurs as a result of dehydration. Infantile diarrhoea is the single most important cause of malnutrition in the tropics. The results obtained in the present investigation suggested that baobab solution is the best for prevention of dehydration and management of diarrhoea.

Baobab solution (solution A) is an effective early home management for diarrhoea. At this stage there is no need for a base which is added in ORS to correct acidosis. The acidic nature of the baobab pulp is due mainly to its high content of acids particularly ascorbic acid (337 mg/100g) which is an antioxidant that neutralize or prevent the damaging effect of free radical[201]. Solution B has optimal electrolyte contents of sodium and potassium.

## CONCLUSIONS

1- Baobab home rehydration solution is safe compared to WHO/ORS in the case of erroneous preparation.

2- Baobab home rehydration solution is effective. Results showed that it is better than ORS specially in the 1st day of application.

3- Baobab home rehydration solution is acceptable as diarrhoea management solution for both children and their mothers compared to ORS. Mothers studied insisted on their children taking baobab rather than ORS.

4- Baobab home rehydration solution has to be offered with great encouragement even in bloody diarrhoea it was effective and acceptable.

5- When ORT is used as home management of diarrhoea the message should be stressed for feeding the child and to continue breast-feeding.

6- Baobab is a nutritious solution as documented by the chemical analysis.

## RECOMMENDATIONS

1- Baobab fruit being available, inexpensive, culturally acceptable can be an ideal home fluid therapy for diarrhoea.

2- If the baobab solution is recommended for use as home ORT, mothers should have guidelines for making an ideal solution.

3- The National Diarrhoeal Disease Control Program should consider advocating baobab strongly as home management for diarrhoea.

4- Baobab is traditionally used as remedy for diarrhoea. Further research should be done to investigate the treatment potential of baobab.

5- Further studies on the use of baobab solution in management of persistant diarrhoea should be considered, with emphasis on the roles of zinc and potassium.

## REFERENCES


1- Balistreri W F : Oral rehydration in acute infantile diarrhoea. Am. J. Med. 1990 88 (6A):305-335.

2- Guandalinj S. Overview of childhood acute diarrhoea in Europe. Implication for oral rehydration therapy. Acta-Paediatr. Scand-Suppl. 1939, 364:5-12.

3- Synder J D, Merson M H: The management of the global problem of acute diarrhoeal disease: A review of active surveillance data. Bulletin of the World Health Orgarization 1982; 60(4):605-613.

4- Louis J P; Trebucq A; Ghadjama M; Arrive P; Foumane, V.; Kalite, T.; Roungou, J. B.: Diarrhoeal diseases in children in the Central African Republic. Epidemiological investigation in the sanitary region No. 3. Medicine-d' Afrigue. Noire. 1991, 38(4):281-284.

5- Yach D, Strebel P M: Joubert, J.: The impact of diarrhoeal disease on childhood death in the RSA, 1968- 1985. S. A. Med. J. 1989 Nov. 4, 76(9):742-5.

6- Mohmud A; Jalil F; Krilberg J, Lindblad B S: Early child health in Lahore, Pakistan. Acta Paediatr. Suppl. 1993, Aug., 82 Suppl. 390:79-85.

7- National Diarrhoeal Disease Control Programme (Sudan). Household Survey, Khartoum 1992.

8- Sudan Demographic and Health Survey (SDHS) (1989-1990).

9- Republic of Sudan Central State M. O. H. and S. W. F. Health profile Jan, 1994.

10-World Health Organization Programme for control of diarrhoeal diseases. Inter. programme report, 1992, 20.

11-Ahmed I S; Karrar Z A; Gebreil A R. Knowledge, attitudes and practices of mothers regarding diarrhoea among children in Sudanese rural community. East African Medical Journal 1994, 71(11):16-19.

12- Ministry of Health/Control of Diarrhoeal Disease Programme (MOH/CDD), 1987. Report on the control of diarrhoeal disease, survey in Elobied town, Ministry of Health, Sudan.

13- National Diarrhoeal Diseases Control Programme (Sudan) Household survey, Khartoum 1992.

14- Ahmed h S; Molla A M: Rice - based oral rehydration. J. Diarrhoeal Dis. Res. 1987; 1:1-6.

15- Ismail R, Pardede N, Darwin S; Nazir M; Mukti S: Home-made rice water salt solution for oral rehydration therapy - A field trial. J. Diarrhoeal Dis. Res. 1996; 1:20-5.

16- Molla A M; Molla A M; Bari A: Role of glucose polymer (cereal) in oral rehydration therapy: Clinical-Therapeutics 1990, 12: Supp A, 113 - 121.

17- National Diarrhoeal Diseases Control Programme. Survey of diarrhoea - related morbidity, mortality and community treatment practices. Ministry of Health, Khartoum, Sudan; 1986.

18- Tierney L M Jr; Mephee S J; Papadakis M A and Schroeder S A: Current Medical diagnosis and Treatment 1993. Appleton and lange volume 1 455-456. Norwalk Connecticut.

19- WHO Programme for Control of Diarrhoeal Diseases. Participant manual, diarrhoea management training course CDD/SER 90-3 1992.

20- Gurrero R: Acute invasive diarrhoea in the pediatric patient. Scand. J. Gastroenterol - Suppl. 1989; 169:24-7.

21- Victora C G; Hutly S R; Fuchs S C; Beau J P; Fauveau V; Chowdhury H R et al.: International difference in clinical patterns of diarrhoeal death, a comparison of children from Brazil, Senegal, Bangladesh, and India. J. Diarrhoeal Dis. - Res. 1993 Mar, 11(1):25-9.

22- Lima A A; Fang G; Schorling J B; de-Albuquerque L; Mc Auliffe J F; Mota S; Leite R; Guerrant R L: Persistent diarrhoea in North east Brazil: etiologies and interactions with malnutrition, Acta - Paediatr. 1992 sep. 81 Suppl. 381-44.

23- Mitchell J E; Donald W D; Charlottesville M B A; review of 396 cases of acute diarrhoea in which early feeding were employed in treatment. The Journal of Paediatrics, Vol. 35 Nov.; 1949 (5):529.

24- Martinez H, Saucedo G: Mothers Perceptions about childhood diarrhoea in rural Mexico: J. Diarrhoeal - Dis. Res. 1991 Sep.; 9(3):235-43.

25- Burleigh E; Oardano C; Cruz J R: Color, humors and evil eye, indigenous classification and treatment of childhood diarrhoea in high land Guatemala. Med. Anthropol. 1990 Nov. 12(4):419-41.

26- Singh J; Gowriswari D; Chavan B R; Patiat R A; Debnath A C; Jain D C; Sharma R S; Sharma R C; Datta K K: Diarrhoeal diseases amongst children under five, A study in rural Alwar. J. Common -Dis- 1992 Sep; 24(3):150-5.

27- Zaman S; Jalil F; Karberg J: Early child health in Lahore, Pakistan child care practices Acta - Paediatr - Suppl. 1993 Aug. 92 Suppl 390:39-44.

28- Leung A K; Robson W L: Acute diarrhoea in children what to do and what not to do. Postgrad. Med. 1989 Decc. 86(8):161-4, 167-74.

29- Gattuso J M, Kalram M A: Adverse effects of drugs used in the management of constipation and diarrhoea. Drug Saf. 1994 jan; 10(1):47-65.

30- Blanco R A: Concepts of pharmacy employees concerning the management of diarrhoea in children. Bol - Med - Hosp -Infant - Mex. 1989 Jul; 46(7):463-9.

31- Reyers H; Jome P; Guiscafre H; Martinez H; Romero G ; Portillo E Rodriouez R, Gutierrez G: The verbal autopsy on children with a respiratory infection and acute diarrhoea. An analysis of the disease - care -death process, Bol. med - Hosp - Infant - Mex. 1993 Jan; 50(1):7-16.

32- Gani L; Arif H; Widjaja J K; Adi R; Prasadja H; Tampubolon L H; Lukito E; Jauri R: Physicians prescribing practice for treatment of acute diarrhoea in young children in Jakarta, J - Diarrhoeal - Dis. - Res. - 1991, Sep; 9(3):194-9.

33- del-Aguila R; Brewn K H: Management of infantile diarrhoea by physicians in outpatients services in Peru. Bol. Oficina-Sani Panam 1993 Oct., 115(4):291 - 300.

34- Barron P M; Ephraim G; Hira M; Kathawarcoo S; Thomas C: Dispensing habits of Johannesburg pharmacists in treating acute infantile diarrhoea. S. Afr - Med. - J. 1989. Nov. 4; 76(9):487-9.

35- Berih A A; Mclntyre L; Lynk A D: Pharmacy dispensing practice for Sudanese children with diarrhoea. Public-Health 1989. Nov.; 103(6):455-8.

36- Parwari A K: Cost effective strategy for promotion of appropriate case management of diarrhoeal diseases. establishment of DTUS. Indian - J. Pediatri. 1991 Nov. dec. 58(6):783-7.

37- Gracey M: Recent advances in childhood diarrhoeal diseases. Acta - Paidiatr - Jpn. 1991 Jun., 33(3):279-83.

38- Desjeux J F; Lestradet H: Oral rehydration solution or physiology in public health. Bull-Acad - Nati - Med. Jan; 174(1):55-60.

39- WHO/CDD/CMT 86./Rev. 1988.

40- Mohalanabis D: Rehydration therapy in diarrhoea, In acute enteric infections in children, New prospects for treatment and prevention 1981. Alsevier / North Holland Biomedical Press. Amsterdam; 303-318.

41- Darraw D C; Pratt E L; Flatt J et al.: Disturbances of water and electrolytes in infantile diarrhoea. Paediatrics 1949; 3:129-

42- W.H.O Programme for control of diarrhoeal diseases. A manual for the treatment of acute diarrhoea, use by physicians and other senior health workers, 1984; WHO/CDD/ser/Bo-2 Rev. 1:18.

43- Guandalini S: Current controversies in ORS formulation. Clinical - Therapeutics, 1990, 12: Suppl. A. 38-50.

44- Ansaldi N et al.: importance of oral rehydration in acute infantile diarrhoea. comparison of two rehydration solutions Minerva Pediatri. 1990 Jan - Feb, 42(2):9-14.

45- Delucchi M A; Guiraldes E; Hirsch T; Nunez N; Schele C; Gutierrez H; Torres - Pereyra J: True use of oral hydration in the treatment of children with acute Gastroenterol - Nutr. 1989 Oct. 9(3)328-34.

46- Elliot E J; Walker-Smith J A; Farthing M J G; Hunt J; Cameron D: Clinical experience with a hypotonic oral rehydration solution for treatment of pediatric gastroeateritis in the United Kingdom - Clinical - Therapeutics, 1990, 12: Suppl. A, 86 - 94.

47- Rautanen T; El-Rahdhi S; Vesikari T: Clinical experience with a hypotonic oral rehydration solution in acute diarrhoea, Acta - Paediatrica. 1993, 82(1):52-54.

48- Cwlghom G J; Shepherd R W; Patrick M K; Chin S E: Comparison of two oral rehydration solutions in children with gastroentrcritis in Australia. Clinical Therapeutics. 1990, 12: Suppl. A 81-85.

49- Velasquez-Jones L; Becerra F C; Faure A; Leon M de Moreno H; Maulen I; Abraham - Jalil A; Muraira A: Clinical experience in Mexico with a new ORS with lower osmolality. Clinical - Therapeutics. 1990, 12: Suppl 95 - 103.

50-Cutting W A; Belton N R; Grey J A; Brettle R P; Welsby P D; Todd W T; Elton R A; Westwood A; Oavidson S: Safety and efficacy of three ORS for children with diarrhoea. Acta - Paediatr - Scand 1989 Mar, 78(2):253-8.

51- Dutta P; Bhattacharya S K; Dutta D; Mitra U; Bhattacharya M K; Rasaily R; Sen D; Saha M R; Mukherjee Pal S C: ORS containing 90 millimole sodium is safe and useful in treating diarrhoea in severely malnourished children. J. Diarrhoeal _ Dis -Res 1991 Jun; 9(2):118-22.

52- Rohde J E: Justification of the composition of WHO formula ORS. J. Indian Med - Asoc. 1993 Sep; 91(9):226.

53- Patwari A K; Kumar H; Anand V K; Aneia S; Sharma D: Diarrhoea training and treatment unit: experience from a teaching hospital. Indian J. Pediatr. 1991 Nov. - Dec., 58(6):775-81.

54- Kudlova E: The fight against diarrhoeal disease in Yemen. Introduction of ORT. Cesk - Pediatr. 1990 Jan., 45(1):35-8.

55- Fauveau V; Yunus M, Islam M S; Briend A; bennish M L: Does ORT reduce diarrhoeal mortality? Health - Policy -and - Planning. 1992, 7(3):243-250.

56 Muraira-Gutierrez A; Mendez-Jara A; Ruiz-Villalpando G: An evaluation of the 4 years of the oral rehydration service of the hospital infantile de Monterry. Bol. Med. Hosp. Infant - Mex. 1992 Jun; 49(6):358-64.

57- Heymann D L; Mbvundula M; Macheso A; Farland D A; Hawkins R V: Oral rehydration therapy in Malawi: Impact on the severity of disease and on hospital admission, treatment practices, and recurrent costs. Bull. World-Health - Organ. 1990, 68(2):193-7.

58- Miller P C: Trends in the management of childhood diarrhoea in Egypt, 1979 - 1990. J. Diarrhoeal - Dis - Res - 1992 Dec., 10(4):193-200.

59- Salazar - Lindo E; Chea - Woo - E; Kohastsu J; Miranda P R: Evaluation of clinical management training programme for diarrhoea. J. Diarrhoeal Dis. Res. 1991. Sep. 9(3):227-34.

60- Patwari A K; Kumar H; Anael V K; Aneja S; Sharma D: Diarrhoea training and treatment unit: experience from a teaching hospital. India N. Pediatri. 1991 Nov. Dec., 58(6):775-81.

61- Speratto G: Rapid intravenous rehydration in acute diarrhoea. Bol. Med. Hos. Infant/ Mex. 1992, Aug.; 49(8):506-13.

62- Isolauri E; Jalonen T; Maki M: Acute gastroenteritis. Changing pattern of clinical features and management Acta - Paediatr Scand, 1989, Sep; 78(5):685-91.

63- Neiberger R E; Pena D R; Eitzman D: Oral hydration therapy for children in Florida. J. Fla. Med. Assoc. 1992, Feb.; 79(2):105-11.

64- Hunt J B; Thillainayagam A V; Camaby S; Fairclough P D; Clark M L; Farthing M J: Absorption of a hypotonic oral rehydration solution in a human model of cholera. Gut. 1994, Feb; 35(2):211-4.

65- Maughan R J; Leiper J B: Studies in human models. Clinical Therapeutics. 1990, 12: Suppl A, 63-72.

66- Brodetj J; Jrause M; Dohring-Schewerdifeger E: Parental rehydration treatment of acute diarrhoea. Monatsschr - Kinderheikd. 1989, Sep; 137(9):574-78.

67- Sperotto G: Rapid intravenous rehydration in acute diarrhoea. Bol. Med. Hosp. Infant. Mex. 1992, Aug, 49(8):506-13.

68- Kallin R J: The management of diarrhoeal dehydration in infant, using parental fluids. Pediatri. Clin - North - Am. 1990, Apr; 37(2):265-86.

69- Ferrero F C; Ossorio M F; Voyer L E; Gonzalez H; Macario M E; Cabeza M: Fast intravenous rehydration with 90 mmol/l of sodium in dehydrated children with diarrhoea. Bol - Med - Hosp - Infant - Mex. 1991, Jul; 48(1):474-8.

70- Bezerra J A; Duncan B; Gaines J A; Udal J N Jr: Treatment of infants with acute diarrhoea: what's recommended and what's practices. Pediatrics, 1992 Jul; 90(1 Pt 1):1-4.

71-Kidowaki T; Funaki H; Mizuta R; Nishiki T; Takada H: Treatment of an infant with congenital sodium diarrhoea by oral rehydration. Acta - Paediatr - Jpn. 1993 Feb; 35(1):49-52.

72- Beau J P; Fontaine O; Garenne M: Management of malnourished children with acute diarrhoea and sugar intolerance. J - Trop - Pediatr. 1989 Dec; 35(6):281-4.

73- Mc Divitt J A; Homik R C; Carr C D: Quality of home use of oral rehydration solution, results from seven health com sites. Soc. Sci - Med - 1994 May, 38(9):1221-34.

74- Tomkins A: Recent development in the nutritional management of diarrhoea.
1- Nutritional strategies to prevent diarrhoea among children in developing countries. Transaction - of - the - Royal - Society - of - Tropical - Medicine - and - Hygiene, 1991, 85(1):4-7.

75- Molla A M; Molla A; Bari A: Role of Glucose polymer (cereal) in oral rehydration therapy. Clinical - Therapeutics. 1990, 12: Suppl A, 113-121.

76- Agwal R; Afzalpurkar R; Fordtran J S.: Pathophysiology of potassium absorption and secretion by the human intestine. Gastroenterology. 1994, Aug; 107(2):548-71.

77- A joint WHO/UNICEF statement. The management of diarrhoea and the use of oral rehydration therapy. WHO 1985; second edition.

78- Baumslag N; Davis R; Mason L G et al: ORT An annotated bibliography PAHO 1980.

79- Mahalanabis D: Rehydration therapy in diarrhoea In: Acute enteric infections in children. New prospects for treatment and prevention 1981. Alsevier/North Holland Biomedical Press, Amsterdam; 303-318.

80- Pelleboer R A A; Jolboom J J M: Oral rehydration solution (ORS) based on food: a promising remedy. Netherlands. Tijdschrift - Voor - Geneeskundu 1993, 137(7):342-345.

81- Ahmed H S; Molla A M: Rice - based oral rehydration J - Diarrhoeal - Dis - Res. Mar 1987; 5(1):1-6.

82- Tierney L M; Mcphae S T; Papadakis M A; Schroeder S A: Current Medical Diagnosis and Treatment, a lange medical book, Appleton and lange 1993; (1):683-684.

83- Martinez-Salgado H; Calva - Mercado - J. J., Mota - Hernandez, F.; Posadas - Tello 1 ; Bross - Soriano, D.: Efficacy of a rice based beverage for the management of dehydration caused by acute diarrhoea in children. Bol - Med - Hos - Infant - Mex. 1991 / Aug; 48(8):544-53.

84- Kenya P R; Odongo H W; Oundo G; Waswa K; Muttungo J; Molla A M; Nath S K; Molla A; Greenough W R: Cereal based ORS. Arch - Dis - child. 1989 Jul; 64(7):1032-5.

85- Fayad I M; Hashem M; Duggon C; Refat M; Bakir M; Fontaine O; Santosham M: Comparative efficacy of rice based and glucose based ORS plus early reintroduction of food. Lancent 1993 Sep 25; 342 (8874) 772-5.

86- Mota - Hemandez F; Pasada - Tello N M; Pordiguez - Leyva G: Rice water with and without electrolyte in diarrhoea with a high stool output. Bol. M. Hosp. infant Mex. 1993 Dec.; 50(12):849-53.

87- Mustafa S A: Glucose based and cereal based ORS in the management of acute diarrhoeal diseases in Sudanese children, Thesis submitted in partial fulfillment of requirement for master of paediatrics and child health (M. P. C. H) 1991.

88- Molla A M; Molla A; Rohde J; Greenough W B: Turning off the diarrhoea: The role of food and ORS. J. Pediatri - Gastroente - rol - Nutr. 1989 Jan; 8(1):81-4.

89- Alam N H; Ahmed T; Khatum M; Molla A M: Effects of food with two oral rehydration therapies: a randomized controlled clinical trial. Gut 1992, 33(4):560-562.

90- Khin - Maung U; Greenough W O: Cereal - based ORT 1. Clinical studies, J - Pediatr. 1991 Apr.: 118(4(Pt 2)):572-9.

91- Santosham M; Fayad I M; Hashem M; Goepp J G; Refat M; Sack R B: A comparison of rice - based ORS and early feeding for the treatment of acute diarrhoea in infant. J. Pediatr. 1990. June, 116(6):868 - 75.

92- Lebenthal E; Lu - R B: Glucose polymer as an alternative to glucose in oral rehydration solutions. J - Pediatr. 1991 Apr.; 118(4(Pt 2):562-9.

93- Pizzaro D; Posada G; Sandi L; Moram J R: Rice based oral electrolyte solution for the management of infantile diarrhoea. N - Fngl. J - Med. 1991 Feb 21; 324(8):517-21.

94- Fakhir S; Ahmed S H: A comparative study of three types of ORS in the management of diarrhoeal dehydration. India - J - Pediatr. 1990 Jan - Feb; 57(1):81-7.

95- Molla A M; Bari A: Role of cereal based ORT in persistent diarrhoea in children. Acta - Paediatrica. 1992, 81: Supplement 381:104-107.

96- Razafindrakoto O; Ravelomanana N; Randriamiharisoa F; Rasoarivao V; Raminalimanana V; et al: Oral rice based rehydration solution (SRO), alternative of SRO of WHO in acute diarrhoea in malnourished patients. Arch - Fr - Pediatr. 1993 Feb; 50(2):101-5.

97- Pietschnig B; Javaid N, Haschke F; Huemer C; Schuster E: Acute diarrhoeal diseases. Treatment with carrot - rice viscous solution is more effective than ORS - Monatsschr - Kinderheikd. 1992 July; 140(7):426-30.

98- Shaikh S; Molla A M; Islam A; Billoo A G; Hendricks K; Snyder J: A traditional diet as part of ORT in severe acute diarrhoea in young children. Journal - of - Diarrhoeal - Diseases - Research. 1991, 9:(3):258-263.

99- Lifschitz C H; Torun B; Cnuv E; Boutton T W; Garza C; Klein P D: Absorption of carbon13 - labeled rice in milk by infants during acute gastroenteritis - J - Pediatr. 1991, Apr; 118(4(Pt 1)):526-30.

100- Grange A: Evaluation of malto - dextrin/glycine oral rehydration solution. Ann - trop - Paediatr. 1992, 12(4):353-8.

101- Abkar M S; Baker K M; Aziz M A; Khan W A; Salim A F: A randomized, double blind clinical trial of a maltodextrin containing ORS in acute infantile diarrhoea. J. Diarrhoeal - Dis - Res. 1991 Mar.; 9(1):33-7.

102- Santos - Ocampo - P D; Bravo L C; Rogacion J M; Battad G R: A randomized double blind clinical trial of a maltodextrin containing ORS in acute infantile diarrhoea. J- Pediatr - Gastroenterol - Nutr. 1993 Jan, 16(1):23-8.

103- Rahman A M; Bari A: Feasibility of home treatment of diarrhoea with packaged rice - ORS. J - Diarrhoeal - Dis - Res - 1990 Mar - Jun; 8(1-2); 18-23.

104- Greenough W H; Khin - Maung - U: Cereal - based ORT - strategic issues for its implementation in national diarrhoeal diseases control programs. J - Paediatr. 1990 Apr; 118(4(Pt2)):580-5.

105- Antony T J; Mohan M: A comparative study of glycine fortfield oral rehydration solution with standard WHO, ORS. Indian - Pediatr. 1989 Dec; 26(12):1196-201.

106-The international Study Group on Improved ORS. Impact of glycine containing ORS solutions stool output and duration of diarrhoea. Bull - World - Health - Organ. 1991; 69(5):541-8.

107- Khin - Maung - U; Myo - Khin; Nyunt - Nyunt - Wai; Mu - Mu - Khin; Mya - Tri; Thein - Thein - Myint. Comparison of glucose/electrolyte and maltodextrin/glycine/glycyl - glycine/electrolyte ORS in acute diarrhoea in children. J - Pediatr - Gastroenterol - Nutr. 1991 Nov; 13(4):397-401.

108- Ribeiro- Junior H da - C; Lifeshitz F: Alanine - based ORT for infant with acute diarrhoea. J - Pediatr. 1991 Apr; 118(4(Pt2)):586-90.

109- Sazawal S; Bhatnagar S; Bhan M K; Saxena S K: Analine based ORS: assessment of efficacy in acute non cholera diarrhoea among children. J - Pediatr - Gastroroenterol - Nutr. 1991 May; 12(4):461-8.

110- UK, Nutritional Consultative Panel: Nutritional and health benefit of milk and milk products. Nutrition - Briefing 1993, No 24, 7. Nutrition - Abstracts - and - review - Series - A 1993: 063 - 07265.

111- Santosham M; Goepp J; Burns B; Reid R; O'Dononvan C; Pathak R; Sack R B: Role of a soy based lactose - free formula in the outpatient of diarrhoea. Pediatrics: 1991 May; 87(5):619-22.

112- Haffejee I E: Cow's milk based formula, human milk and soys feeds in acute infantile diarrhoea: a therapeutic trials. J - Pediatr - Gastroenterol - Nutr. 1990 Feb; 10(2):193-8.

113- Macleod J; Edward C; Bouchier I: Davidson;s Principles and Practice of Medicine 15th, ELBS 1987:718,52.

114- Rohde J E; Cash R; Mahalanabis D; Molla A M; Ozalp I Therapeutic intervention in Diarrhoea. Food and Nutrition Bulletin Vol. 3, 1981 Octo (4):34-35.

115- Van Maydell H J: Trees and shrubs of the sahel. Their characteristics and uses 1990. Verlag Josef Morgraf Weikersheim, P. 149-153.

116- Ramesh D; Dennis T J; Shingare M S; Constituents o f Adansonia digitata root bark. Fitotherapia. 1992, 63(3):278-279.

117- Grand Ale; Le - Grand A: Anti-infectious phototherapies of the tree savanna. Senegal (West Africa). a summary of the phytochemical substances and the antimicrobial activity of 43 species - Journal of Ethropharmacology - 1989, 25(3):315-333.

118- Van Maydell H J: Trees and shrubs of the sahel. their characteristics and uses. Eschborn 1986:90.

119- Mohamed El amin H; Trees and shrubs of the Sudan 1990 Ithaca Press Exeterp:113.

120- Thirakul S; Manual of Dendrology, Bahr el Ghazal and central regions. Forest inventory project area. Demographic Republic of the Sudan, prepared through the assistance of the Canadian International Development Agency by consultant Quebec Canada June 1984.

121- Sahni K C; The important trees of the Northern Sudan 1968 Khartoum :30.

122- Sipra - Dan; Dan S S Phytochemical study of Adansonia digitata, Coccoloba excoriota, Psychotria adenophylla and Schleichera oleosa. Fitoterapia. 186, 57(6):445-446.

123- Adesanya S A; Idowu I B; Elujoba A A: Antisickling activity of Adansonia digitata Planta Medica, 1988, 54:4, 374.

124- Wilson R T: Vital statistics of the baobab Adansonia digitata. African - Journal - of - Ecology. 1968, 26:3, 197-206.

125- Obizoba I C; Amaechi N A: The effect of processing on the chemical composition of baobab Adansonia digitata pulp and seed. Ecology - of - Food and Nutrition. 1993, 29(3): 199-205.

126- Laurent C: The development of a flour used in weaning foods. les malnutritions dans les pays du tiers - Monde. 1986, 557. Nutrition - Abstracts and Reviews Series A 1988, 058 - 03271.

127- Nkana Z G; Iddi S: Forestry Abstracts 1994, 055- 12530.

128- Prentice A; Laskey M A; Shaw J; Hudson G J; Day K C; Jarjou L M A; Dibba B; Paul A A; British -Journal - of Nutrition 1993, 69(3):885-896.

129- Saka J D K; Msonthi J D; Sambo E Y: Dry matter, acidity and ascorbic acid contents of edible wild fruits growing in Malawi. Tropical-Science. 1992, 32(3):217-221.

130- Eromosele T C; Eromosele C O; Kuzhkuzha D M: Evaluation of mineral elements and ascorbic acid contents in fruits of some wild plants. Plant - Food For - Human Nutrition 1991, 41(2):1151-154.

131- Ibiyemi S A; Abiodun A; Akanji S A Adansonia digitata Bomox and Parkia filicoideae Welw fruit pulp for safe drink industry. Food Chemistry. 1988, 28(2):111-116.

132- Magboul B I and Mustafa A I: Studies on baobab seed oil. Sudan - J - Food Sci. Technol, 1979, 11:10-14.

133- Kssien A L; Fetuga B L: Beta - carotene content and some characteristics of under exploited seed oils of

forest trees in Nigeria. Food - Chemistry 1989, 32(2):109-116.

134-Nour A A; Magboul B I; Kheirr N H: Chemical composition of baobab fruit Adansonia digitata L. Trop. Sci. 1980, 22(4):383-388.

135- Tertain R; Claisse F: Principles of quantitative X-ray fluorescence Analysis. London 1982.

136- Pearson D: The chemical analysis of foods, seventh edition 1976. Churchili Livingstone.

137- Carlson L A: Determination of free nicotic acid in blood plasma. Clinica Chim. Acta 1966,13:349-351.

138- Magboul B I: Studies on experimental niacin depletion in the rat. Thesis submitted in partial fulfillment of the requirements for the degree of Ph. D. in the university of London December, 1981, 54-55.

139- Lucas A: feeding the normal infant, Medicine International 1994, Octo, 22(10) Nutrition:397-401.

140- Prentice A; Laskey M A; Shaw J; Hudson Paul A A: The calcium and phosphorous intakes of rural Gambian women during pregnancy and lactation, British - Journal - of - Nutrition, 1993, 69(3):885-896.

141- SCN New (A periodic review of developments in international nutrition compiled from information available to the ACC/SCN Administrative committee on coordination - subcommittee on nutrition No(9) 1993:24-27.

142- Sachdev H P; Mittal N K; Yadav H S: Oral zinc supplementation in persistent diarrhoea in infants: Ann. trop. Paediatr. 1990 Mar; 10(1):63-9.

143- SCN New No(9) 1993:33-34.

144- Tierney L M; Mcphee S J; Papadakis M A; Schroeder S A: Current Medical Diagnosis and Treatment, a lange medical book 1993, Appleton and Lange, Norwalk Connecticut (11):993.

145 Loeb H; Vanotenplas Y; Mursch P; Guesry P: Tannin rich carob pod for the treatment of acute on set diarrhoea. J. Pediatr. Gastroenterol - Nutr. 1989 May; 8(4):480-500.

146- Lehert G; Stadelman G; Schaller K H and Szadkowski D; Arch, Hyg. Bakt., 1969:153, 403.

147- Harley J H; Envir Sci. Technical, 1970(4):225.

148- Jathar V S, Pendharkar P B; Raut S J; Panday V K: Intake of lead through food in India, Journal of Food Science and Technology Nov. - Dec, 1981, 18(6):240-2.

149- Toury J; Lunren P; Giorgi K, and Jacquesson N: Adansonia digitata L: to value ti native Africans. Ann. Nutr. Aliment 1857, 2(6):99-102 (cited in Chem. Abstr., 1958,52,14889 g).

150- Oliviera J F S: The nutritional value of some foods consumed on San Tome Island Ecol. Food Nutr. 1974(3):237-242.

151- Martina D W; Mayes P A; Rodwell V W; Harper's Review of Biochemistry, 18th edition, lange medical publication 1981, p 97.

152- Eastwood M: Dietary fibre in human nutrition, Journal - of - Dairy - Technology. 1989, 42(2):33-34.

153- Nair B M; Asp N G; Nyman M; Pearson H: Binding of mineral elements by some dietary fibre components in vitro, Food Chemistry, 1987, 23 (4):295-303.

154- Seal C; Mathers J C: Intestinal zinc transfer by everted gut sacs from rats given diets containing different amounts and types of dietary fibre, British - Journal - of Nutrition, 1989, 62(1):151-163.

155- Rowland I R; Mallett A K: Dietary fibre and the gut microflora, their effect on toxicity, development in Toxicology and Environmental Science 1986 Vol. 12:125-138.

156- Madhour A A; Madina E M; el. Azzouni O E; Amer M A; el. Walili T M; Abbas I: Smectite in acute diarrhoea in children, J - Pediatr. Gastroenterol - Nutr. 1993 Aug: 17(2): 176-81.

157- Vivatvakin B; Jongpipatvanich S; Harikul S; Eksoengri P; Lortholary O: Control study of oral rehydration solution in hospitalized Thai infants with acute secretary diarrhoea. Southeast - Asian - J - Trop - Med. Public - Health 1992 Sep, 23(3):414-9.

158- Thillainayagam A V; Camaby S; Dias J A; Clark M L; Fathering M J: Evidence of a dominant role for low osmolality in the efficacy of cereal based ORS Studies in a Model of secretory diarrhoea, Gut 1993, Jul, 34(7):920-5.

159- Thillainayagam A V; Dias T A; Salim A F; Mourad F H; Clark M L; Farthing M J: Glucose polymer in the fluid therapy of acute diarrhoea: Studies in a model of rotavirus infection in neonatal rats. Clin - Sci. - Colch. 1994 Apr, 86(4):469-77.

160- Mallet E; Guillot M; Luyer BLè; Morin C; Pollet F; Meynard Cde; Le-Luyer, B.: Comparison of two oral rehydration solution in eutrophic infants with moderate acute diarrhoea. Clinical - therapeutics - 1990, 12: Supp A, 104 -112.

161- Wall C R; Shepherd R W; Patrick M; Chin S; Cleghom G: Osmolality electrolyte and carbohydrate type and oral rehydration solutions. A controlled study to compare the efficacy of two commercially available solutions. J. Diarrhoel - Dis - Res - 1993 Dec, 11(4):222-6.

162- Rolston D D; Raghupathy P; Cutting W A: Effect of a maltodextrin - electrolyte, a maltodextrin - nutrient - electrolyte and a standard electrolyte solution on water and electrolyte fluxes in the secreting rat intestine. J. Diarrhoeal - Dis - Res - 1993 Dec; 11(4): 217-21.

163- Rautanen T; Solo E; Verkasalo M; Vesikari T: Randomized double blind trial of hypotonic ORS with and without citrate Arch - Dis - Child - 1994 Jan; 70(1): 44-6.

164- Habte D; Stintzing G; Thoren A and Mollby R: Epidemiology of acute diarrhoeal disease in children in Addis Ababa. In acute enteric infection in children: New prospects for treatment and prevention. Elsevier / North Holland Biomedical Press 1981; 133 - 139.

165- ACC/SCN Supplementary Feeding Counteracts Effects of Diarrhoea on Growth SCN New 1990, No. 5:33-36.

166- Lutter C K; Habicht J P; Rivera J and Mantorell R: The relationship between energy intake and diarrhoeal disease in their effects on children growth. Biological model, Evidence and implication for public health policy. Food and Nutrition Bulletin 1992, 14(1):36-42.

167- Materia E; Mehari W; Mele A; Rosmini F; Stazl M A; damen H M; Basile G; Miuccio G; Ferrigno L; Miozzo A; et al. A community survey on maternal and child health services utilization in rural Ethiopia. Eur - J - Epidemiol 1993 Sep; 9(5):511-6.

168- Haffman S L; Combest C: Role of breast feeding in the prevention and treatment of diarrhoea. J - Diarrhoeal - Dis - Res - 1990 Sep; 8(3):68-81.

169- Tierney L M; Mcphee S J; Schroeder S A: Current Medical Diagnosis and Treatment 1993; Vol. I Appleton and lange, Norwalk Connectict :611, 456.

170- Barros F C; Victoria C G; Forsberg B; Maranhao A G K; Stegeman M; Gonzales - Richmond A; Martins R M; Neuman Z A; Mc Auliffe J; Bramnco J A: management of childhood diarrhoea at the household level: a population based survey in North -east Brazil Bulletin of the world health organization 1991, 69(1):59-65.

171- Hudson P M: ORS and the treatment of childhood diarrhoea in Managua, Nicaragua. Social - Science and Medicine. 1993, 37(1):97 - 103.

172- A/ Wahab M M: Traditional practice as a cause of infant morbidity and mortality in Juba area (Sudan). Annals of Tropical Paediatrics 1987(7):18-21.

173- Yousof H I; Adam A S; Agal K A; Omer A M; Ibrahim M M: Traditional Medical practices in some Somali communities, J. of Trop. Paediatr 1984, 30(2):87-92.

174- Konde - Lule J K; Elasu S; Musonge D L: Knowledge, attitudes, and practices and their policy implications in childhood diarrhoea in Uganda. J - Diarrhoeal - Dis - Res - 1992 Mar; 10(1):25-30.

175- Martinez - salgado H; Calva - Mercado J J; Meneser - Diaz - L M; Viaias - Juarez H: The use of beverages and food at home during acute infantile diarrhoea. an ethnographic study in a rural Mexican area. Bol. med. Hosp - Infant - Mex. 1991. Apr.:48(4): 235-42.

176- Sood A K; Kapil I J: Knowledge and practices among rural mothers in Haryana about childhood diarrhoea. Indian - J - Pediatr. 1990 Jul - Aug: 57(4):563-6.

177- Touhami M; Boudraa G; Adlaouj M; Telidji Z; Soltana R; Mary J Y; Desjeuz J F: Is the dilution of milk necessary in benign acute diarrhoea in eutrophic infant Arch - Fr. Pediatr. 1989 Jan, 46(1):25-30.

178- Isolauri E; Juntunen M; Wiren S; Vuorinen P; Koivula T: Intestinal permeability changes in acute gastroenteritis: effects of clinical factors and nutritional management. J - Pediatr - Gastroenterol - Nutr - 1989 May; 8(4):466-73.

179- Anokbonggo W W; Adoi - Adome R; Oluju P M: Traditional methods in management of diarrhoeal diseases in Uganda, Bull World - Health - Orgam, 1990; 68(3):359-63.

180- Azim S M; Rahaman M M: Home management of childhood diarrhoea in rural Afghanistan: a study in Uganda, Paktika Provine. J - Diarrhoeal Dis- Res. 1993 Sep; 11(3):161-4.

181- Lamikanra A; Alke - Nai - At; O. La - O: Incidence of multiple antibiotic resistance in organisms isolated from cases of infantile diarrhoea in a Nigerian oral rehydration therapy clinic. Ann - Trop - Paediatr. 1989 Dec; 9(4):256-60.

182- Mahalanabis D; Faruque A S G; Wahed M A: Energy dense porridge liquified by amylase of germinated wheat - Use on infants with diarrhoea. Acta. Paediatrica 1993, (82): 617, 603 - 604.

183- Golden M H N and Jackson A A: Chronic severe. In present knowledged in nutrition, 1981, 5th ed. (ed. R. E. Olsen) Wegtheral D J; ledingham J G G and Warrel D A: Oxford Textbook of Medicine 1983, vol 1, 8.13 Oxford University Press. Oxford New York.

184- Hoekstra J H: Oral rehydration treatment in Europe. Nederlands - Tydschrift - voor. Geneeskunde. 1993, 137(7):331-3.

185- The recommendations of the European Society for Paediatrics Gastroenterology and Nutrition and the Commercial availability of ORS. Journal of Pediatric Gastroenterology and Nutrition 1992 14:113 -115.

186- Wegttherall D J; Ledingham J G G; Warrel D A: Oxford Textbook of Medicine vol. 1: 8.25 - 8.26. Oxford University Press. Oxford New York.

187- Subramanian V and Jambunathan R (1984) In: Nutritional and processing quality of sorghum (Salunkhe, D. X. Charan, Jx and Jadhaw, S. J. Eds.) Oxford and IBH Publ. Co. India, p32.

188- Hulse J H; laing E M and Pearson O E (Eds.) (1980). Sorghum and the millets: Their composition and nutritive value, Academic Press. New York.

189- Mustafa S A; Karrar Z A and Gaafar I S: Cereal based oral rehydration solutions in Sudanese children with diarrhoea: a comparative clinical trial of rice based and sorghum based oral rehydration solutions. Annals of Tropical Paediatrics 1995; 15:313-319.

190- Vreede W B; Van - der - Vorst M M: Erroneously prepared oral rehydration solution life - threatening Ned. Tijdschr - Geneeskd 1993 Feb; 137(7):365-6.

191- Islam M A; Kafoed P E; Begum S: Can mothers safely prepare Labon - gur - salt - sugar solution after demonstration in a diarrhoeal hospital? Trop. Geogr - Med. 1992 Jan; 44(1-2):81-5.

192- Muninjaya A A; Widarasa T; Soetjiningsih: Home treatment of acute diarrhoea in Bali, Indonesia, J - Diarrhoeal - dis - res - 1991 Sep; 9(3):200-3.

193- Wagstaff L A; Mkhasibe C: Infant diarrhoea in Soweto - how much oral rehydration therapy? S - Afr - Med - J. 1989 Nov. 4; 76(9):489-91.

194- Edginton M E: Oral rehydration solutions in section 30 areas. A study in two farming districts in the Southern Transraal. S - Afr - Med - J. 1989 Nov 4; 76(9):509-10.

195- Pugh A: Oral rehydration therapy in Zimbabwe. S - Afr - Med - J. 1989 Nov 4; 76(9):511-2.

196- Vemon A A; Toylor W R; Biey A; Mundeka K M; Chahnazarian A; Habicht H; Mutombo M; Makani B: Changes in use of health services in a rural health zone in Zaire - Int - J - Epidemiol. 1993; 22 Suppl 1:520-31.

197- Yartey J; Harisson E K; Brakohiapa L A; Nkrumah F X: Carbohydrate and electrolyte content of some available fluids used for oral rehydration in Ghana. J - Trop - Pediatr. 1993 Aug. 39(4):234-7.

198- Fagundes - Neto - U; Franco L; Tobacow K; Machado N L: Negative findings for use of coconut water an oral rehydration solution in childhood diarrhoea. J. Am. Coll. Nutr. 1993 Apr:12(2):190-3.

199- Adams W; Bratt D E: Young coconut water for home rehydration in children with mild gastroenteritis. tropical and Geographical - Medicine. 1992, 44(1-2):149-153.

200- Sabchareon A; Chongsuphajarsiddhi T; Kittikoon P; Chanthavanich P: Rice powder salt solution in the treatment of acute diarrhoea in young children. Southeast - Asian - J - trop. med. Public - health. 1992 Sep; 23(3):427-32.

201- Elia Marinos: Artificial feeding: Requirements and compositions. Medicine International Oct., 1994; 22(10):414.

202- FAO. 1982: Food composition Tables for the Near East. FAO Food and Nutr. Paper 26. Food and Agri. Organization United Nations, Rome.

203- Mustafa Abdulla M; Salih Hassan M; El Bushra Satti A; Rahim Mohamed El Fatih Ahmed, Izzeldin, A. Kamil, Attitudes and practice of breast feeding in Sudanese urban and rural communities. Tropical and Geographical Medicine 1993, 45(4):171-4.