

Preparation of Rice Based ORS by Solution Method

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Abstract: A new method has been established to make rice based ORS through absorption of salts in rice by soaking the rice in the solution of salts. The soaked rice was dried, fried, powdered and packaged. The rice powder thus prepared when mixed with water in the desired proportion, the suspensions contain Na⁺, K⁺ and Cl⁻ as prescribed. The process is named 'solution method' according to the preparation procedure.

Keywords: Diarrhoea, Rice-based ORS, Absorption, Solution method

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1. Introduction

The World Health Organization (WHO) terms passing of three or more loose stools in the last 24 hours as diarrhoea. This is true for infants and adults. But the attention is for the infants because still 3 million children die of diarrhoea around the world according to the report of The United Nation Children Fund (UNICEF). WHO recommends the glucose based ORS that contains the right amount of salts for the diarrhoea patients. Oral rehydration therapy (ORT) using the glucose-based Oral Rehydration Salts (ORS) solution is the preferred method for treating most children with dehydration due to diarrhoea (except those with severe dehydration) and it has been used successfully in millions of cases worldwide. In many countries glucose-ORS solution is also recommended for home treatment of children with diarrhoea after they have been treated in clinics, even when there are no signs of dehydration. Glucose-ORS solution works because glucose is rapidly absorbed by most patients with diarrhoea, and this causes salt and water also to be absorbed, thus replacing the fecal losses.

The glucose based ORS is costly for the poorer segment of the population and sometimes it may cause osmotic diarrhoea due to its high osmolarity. So producing ORS from local raw material or household material is worthwhile option.

The cereal based ORS was first prepared in 1980 and several clinical trials had been performed on rice-based ORS (R-ORS) in between 1981 and 1996. During this period, the feasibility and superiority of R-ORS over the glucose based ORS had been reported. Initially R-ORS faced several limitations like lack of

cost effectiveness, lack of stability, shorter self life and of course, need for cooking. Then precooked rice based ORS (Pc. R-ORS) was proposed to overcome all the limitations of R-ORS. But it had also short self life and was available in twin packets and thereby costly. So the hydrolyzed R-ORS with high gluco-polymers, a kind of precooked R-ORS, was proposed. It was available in single packet. But it has the discrepancies of high osmolarity which can cause osmotic diarrhoea. Then somehow, all the variations of R-ORS were found to be inferior to the glucose based ORS. To overcome these discrepancies, in 1993, Roy [1] had developed a precooked rice based ORS which had low osmolarity and a shelf life of 6-8 months. After 3 years of its development, an extensive study was made over its performance by putting it to a clinical trial in International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) for three months in 1996 by Bari [2]. In 2000, Sonia and Chinu [3] worked on qualitative assurance of rice based ORS.

The outcomes of this clinical trial are listed below [2]:

- Pc. R-ORS with low glucose polymers is more efficacious than glucose based ORS in respect of more recovery rate by day 3, shorter duration of diarrhea, less ORS solution use, less stool output and better rehydration.
- Normal feeding and early feeding does not interfere the efficacy of Pc. R-ORS with low glucose polymers and glucose based ORS.
- Pc. R-ORS with low glucose polymers has a good packet life and low osmolarity.
- It does not need cooking.

From the above results, it is obvious that this Pc. R-ORS is better than glucose based ORS in every aspect. It also encourages the rice salt solution at home in case

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of the scarcity of packet ORS. The cost of the Pc. R-ORS depends on the price of rice. However, a suitable and proper manufacturing process to produce Pc. R-ORS on a large scale will reduce its cost.

Combining the two substances - fried rice powder and salts into one single mixture in an efficient way and maintaining its quality are the challenges for developing a manufacturing process to produce Pc. R-ORS at affordable price. The solution method for Pc. R-ORS aims at achieving above objectives.

2. Mechanism and Requirements of Pc. R-ORS

The advantage of using rice-based ORS is that glucose is slowly released. It results no accumulation across the cells and promotes sodium absorption. Because of its relatively large polymeric structure hyperosmolarity may cause but amino-acid and peptides liberated from digestion of rice, proteins may further enhance sodium absorption.

Polysaccharides and legumes (mainly amylopectin and amylose) are hydrolysed by pancreatic juice and saliva into short chain glucose-polymers. These are hydrolysed by mucosal glucosides into glucose for absorption. So, a larger amount of rice powder 80 g/l, in a ORS formulation confirmed that it is highly absorption efficient than glucose-ORS [1].

The use of synthetic-amino-acids and peptides is based on evidence that they are capable of promoting water and salt absorption by the mechanism that are distinct from glucose. This provides an additional benefit.

Bari [2] reported that further enhancement of the absorption of sodium and water from the small intestine through the water-soluble organic solute-linked transport, without imposing an osmotic penalty due to unabsorbed organic components can be possible by the use of :

1. Suitable polymers (polysaccharides, proteins).
2. Mixtures of rapidly absorbed organic molecules (d-hexoses, amino-acids).
3. Complex and variable mixtures of polysaccharide, proteins, amino-acids.

The mixing of ingredients shortens the duration of treatment. There is significant difference between the use of only glucose and glucose-glycine which provide significantly better results. To maximize absorption, rice-based ORS, formulation should be such that it can release: glucose = 110-160 mmol/l, Na^+ = 90 mmol/l, K^+ = 20 mmol/l and Cl^- = 80 mmol/l which are close approximation of the recommendation of WHO.

3. Experimental Work

Different experiments were performed to collect enough data to design a feasible process. After every

experiment, a decision was taken to modify the process. The following steps had been followed [4]:

1. Moisture content of rice
2. Water absorption capability of rice
3. Soaking of rice in NaCl solution
4. NaCl content in the rice powder
5. Soaking of rice in the combined solution of three salts (NaCl, KCL, Na-Citrate)
6. Final test and reuse of solution of the salts

3.1. Moisture Content of Rice

This experiment was carried out to determine how much moisture rice contains at room temperature. This moisture content of rice also indicates how much drying is required to get bone dry rice. As the bone dried rice would help to use a standard concentration of salt solution for the required absorption of salts in the rice.

Figure 1 shows the plot how the weight of rice decreases as drying time progresses two samples weighing 5.111 and 100.046 g while the oven temperatures were maintained at about 105°C. This temperature makes the rice pathogen and organism free.

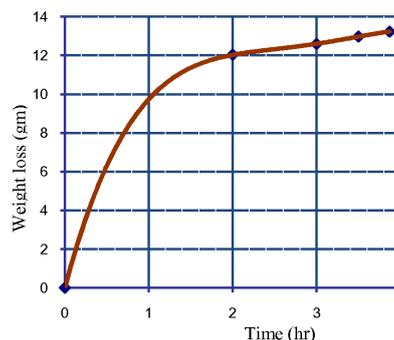


Figure 1: Plot of wt. loss per 100 g of rice during drying

3.2. Water Absorption Capability of Rice

The objective of this experiment was to determine the water absorption capability of rice. This characteristic of rice is very important for the preparation of rice based ORS by solution method. The time required for absorbing water into the rice is crucial from the view point of industrial production because this soaking time will determine the time required for preparing ORS.

From the same batch of Atop rice, 9 samples each having 50 g rice were used to determine water absorption characteristics of rice using different soaking time ranging from 15 minutes to 3 days.

Figure 2 shows the plot describing the water absorbing behavior of rice (non-dried).

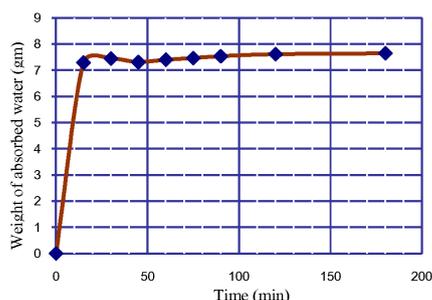


Figure 2: Plot of wt. loss per 100 g of rice during drying

3.3. NaCl solution soaking of rice

Before soaking rice in all types of salt solution, a single salt solution was used for the determination of salt absorption characteristics of rice in the pores. This salt retained in the rice pores would be liberated in water when reconstituted as suspension and the salt content of rice would be known. This step of experiment was important because if rice fails to pick enough salt, then the process would be infeasible.

Two samples of bone dried rice (A & B) weighing 40 g each were taken. The sample 'A' was soaked in 17% NaCl solution and sample 'B' was soaked in 16% NaCl solution. The salt solutions were made with the tap water that contains 143 mg/l of Cl^- ion.

The samples were fried at 160°C as glucose decomposes over 170°C . Also the rice was not turned into puffed rice. The color of rice powder was creamy and smelled like horlicks.

Table 1 shows the data on NaCl solution soaking behavior. The weight gained by the rice was based on the initial weight of the sample.

Table 1: Weight gain of rice with NaCl

	Sample A (g)	Sample B (g)
Initial weight	40	40
Weight (rice + salt)	44.95	43.263
Weight gained	4.95	3.263
Weight gained in % of rice	12.375	8.16

3.4. NaCl content in the rice powder

The NaCl content in the rice powder determines whether the concentration of the solution prepared for the experiment was correct or not. If the liberated NaCl in the water is satisfactory in amount then the solution concentration is correct. But if the liberated NaCl is in excess amount then the solution concentration is to be lowered. By manipulating the concentration of the NaCl solution, the correct concentration of the solution is found.

Two samples (one washed and one unwashed) were soaked in 17% solution of NaCl. Table 2 provides data on NaCl content of the soaked rice after frying and

Table 2: NaCl content of rice

	Washed rice sample(g)	Non-washed rice sample(g)
Rice taken	40	40
NaCl content	2.22	1.66

grinding. However, required NaCl content in 40 g rice sample is 1.75 g. So the washed rice sample was soaked in a 16% salt solution for the next experiment. Two 10 g of samples from the fried powdered rice sample were mixed with water and tested in heated and non heated condition.

Table 3 shows data on NaCl content of rice when rice is soaked in the solution of 16 % NaCl at heated and normal temperature.

Table 3: NaCl content of rice at different conditions

	Heated condition	Non heated condition
Powdered sample taken	10 g	10 g
NaCl content	0.476 g	0.476 g

3.5. Soaking of rice in combined solution of three salts

The solution method which was to be designed lied on the fact that the rice is to be soaked in the solution containing all the salts and fried rice must contain those salts in correct amounts when reconstituted in water.

Table 4 provides data on the tests performed with the combined solution of NaCl, KCl, tri-Sodium Citrate at heated and non-heated condition for fried powdered rice.

Table 4: Cl^- content of Pc. R-ORS at different condition

	Heated condition	Non heated condition
Powdered sample taken	80 g	80 g
Cl^- content	0.109 moles	0.093 moles

3.6. Final test and reuse of solution of the salts

The economy of the process depends on how the use of different raw materials can be optimized. Rice was the raw material which got used up at its optimum quantity. But it was the solution of the salts which was to be optimized by recycling and make up. Otherwise the procedure of preparing rice based ORS by solution method would be uneconomical.

Experiments were performed for two samples by soaking bone dry rice in the same salt solution successively under heated and non heated condition. The sample size was 10 g. Group A samples were soaked in heated and group B samples were soaked in non-heated solution successively and respectively.

Table 5 provides data on the tests performed on determining the Cl^- content of the Pc. R-ORS by dissolving 10 g of Pc. R-ORS in 400 ml of water.

Table 5: Cl^- content in Pc. R-ORS

Sample	Cl^- (in 80 g) (mole)
A1	0.122
A2	0.104
B1	0.095
B2	0.090

Table 6: Na^+ and K^+ content in Pc. R-ORS

Sample	Amount of Na^+ (in 1L solution) (mole)	Amount of K^+ (in 1L solution) (mole)
A1	0.139	0.036
A2	0.098	0.031
B1	0.093	0.026
B2	0.0918	0.024

Table 6 provides data on the absorption of the Na^+ and K^+ content of the rice after soaking in the solution of three salts (NaCl, KCl, tri-Sodium Citrate) in 80 g of rice.

4. Discussion

Several experiments were performed in the laboratory to evaluate every stage of the method of ORS preparation. Some experiments were performed on a trial and error basis to generate specific data for different steps of the method. The results obtained from different stepwise experiments are discussed below:

1. The amount of moisture present in the rice is a factor for absorption of salts in solution. If the moisture is properly removed before soaking in solution, more solution can be absorbed in rice. Most of the moisture (about 94%) is removed from rice in the first 2 hours of drying. Moisture in rice is 15.23 % by weight on dry basis.
2. Maximum 8 g of water can be absorbed by 50 g of rice and 90% of water is absorbed in first 20 minutes, Figure 2.
3. The same characteristic was observed during the soaking rice into NaCl solution. 16% NaCl solution was used as the soaking medium for the bone dry rice.
4. The washed sample of rice soaked in 16% NaCl solution was found to contain more than the desired amount of NaCl salt. But the non-washed sample can absorb less amount of salt than the washed one. So washed rice sample was preferred for this purpose.
5. Three salts - NaCl, KCl and tri-Sodium citrate from a solution were absorbed by the rice in the desired proportion of dissociated ions. Between hot water and water at room temperature, the water at room temperature is preferred as the medium for Pc. R-ORS preparation because the salt absorbing capability of rice at an elevated temperature did not improve much.

6. The suspension of the prepared Pc. R-ORS was found to contain 0.09, 0.0918 and 0.024 moles of Cl^- , Na^+ and K^+ ions per liter of solution respectively. The desired amount of ions in 1 liter of solution is 0.08 moles of Cl^- , 0.09 moles of Na^+ and 0.02 moles of K^+ . The results look like a close match.

Based on the results, it is concluded that the method named 'solution method' is feasible. This method can also be scaled up for the large scale production.

5. Precautions to Maintain the Quality of ORS

1. The drying time of rice has to be enough to destroy any bacteria and spores.
2. The temperature of drying of rice should be maintained at 105°C for only removing water primarily but not frying the rice.
3. At 160°C, the rice should be fried. The temperature should not be higher than this because Carbohydrates may decompose.
4. The powder should not be packed in aluminium foil as the Pc. R-ORS contains chloride ions.
5. The Pc. R-ORS powders are to be packed in air-tight packets.

6. Conclusion

The analyses of the prepared Pc. R-ORS show that it has all the qualities of a proper ORS as per the guidelines of WHO. This new method can also become handy for a large scale production with some small modifications. A pilot study on the process will make its commercialization a success.

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References

- [1] Roy S, *Cereal Based ORS*, B. Sc. Engg. (Chemical) Thesis, Department of Chemical Engineering, Bangladesh University of Engineering and Technology, Dhaka, 1993
- [2] Bari A, *Efficacy of Precooked Rice-ORS and Glucose-ORS to Treat Acute Watery Diarrhoea of Children in Bangladesh*, Master's thesis, Health Development Program, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand, 1996
- [3] Sonia ZF and Chinu KJ, *Rice Based ORS*, B. Sc. Engg. (Chemical) Thesis, Department of Chemical Engineering, Bangladesh University of Engineering and Technology, Dhaka, 2000
- [4] Kirtania K and Nath D, *Preparation of Rice Based ORS by Solution Method*, B. Sc. Engg. (Chemical) Thesis, Department of Chemical Engineering, Bangladesh University of Engineering and Technology, Dhaka, 2008