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Review Article

INTEGRATIVE ROTAVIRUS DISEASE MANAGEMENT: A SIDDHA PERSPECTIVE ON RICE-BASED ORS *(NERPORI KANJI)* INCORPORATED WITH HYBRID PROTEIN-CARBOHYDRATE NANO-CARRIERS

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ABSTRACT

Rotavirus-induced diarrhoea remains a leading cause of dehydration and morbidity among infants and young children, particularly in low-resource settings. Conventional oral rehydration solutions (ORS) effectively restore fluid and electrolyte balance but lack components that promote intestinal healing and sustained nutrient delivery. This review proposes an integrative approach from a Siddha perspective by combining traditional rice-based ORS *(Nerpori Kanji)* with hybrid protein–carbohydrate nano-carriers to enhance therapeutic efficacy. The objective is to improve rehydration while supporting gut recovery and microbiota balance. This paper discusses using rice starch and rice protein to enable controlled electrolyte release, improved bioavailability, and targeted intestinal action. The formulation was evaluated for hydration efficiency, nutrient delivery, and gut-supportive properties. Results indicate improved fluid retention, sustained glucose-mediated electrolyte absorption, and potential prebiotic effects that may aid in restoring gut integrity during rotavirus infection. This dual-action system integrates traditional dietary therapy with nanotechnology, offering a novel, cost-effective, and biocompatible alternative to conventional ORS. The findings suggest that rice-based biomaterials can be engineered to provide both rehydration and intestinal protection, with potential applications in paediatric care. Further in vivo and clinical studies are recommended to validate its therapeutic efficacy and scalability.

INTRODUCTION

Rotavirus remains a leading cause of acute gastroenteritis in infants and young children worldwide, contributing significantly to morbidity and mortality, particularly in low-resource settings. Before the widespread implementation of vaccination programs, rotavirus infection accounted for nearly 500,000 deaths annually among children under five years of age, and it continues to pose a substantial public health burden despite improved immunization coverage [5]. The virus is primarily transmitted through the faeco-oral route via contaminated food, water, and surfaces, leading to clinical manifestations such as profuse diarrhoea, vomiting, fever, and rapid dehydration [3].

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The cornerstone of management for rotavirus-induced diarrhoea is oral rehydration therapy (ORT), which functions by enhancing sodium and water absorption through glucose-mediated co-transport mechanisms in the small intestine[5]. Although conventional glucose-based oral rehydration solutions (ORS) are effective in correcting dehydration, they have limited impact on intestinal recovery and do not actively support mucosal healing or restoration of gut function.

In this context, rice-based ORS has emerged as an effective alternative due to its complex carbohydrate composition. Unlike simple glucose solutions, rice-derived carbohydrates undergo gradual digestion, resulting in sustained glucose release, improved electrolyte absorption, reduced stool output, and shortened duration of diarrhoeal episodes[3]. Additionally, rice components, particularly rice bran,

are rich in bioactive compounds such as phenolics and tocopherols, which exhibit antioxidant and gut-protective properties that may aid in intestinal recovery [6].

Traditional Siddha medicine advocates the use of rice-based preparations such as *Nerpori Kanji* (popped rice gruel) in the management of gastrointestinal disorders, emphasizing their role in restoring hydration, improving digestion, and supporting overall physiological balance [1]. Integrating such traditional knowledge with modern scientific advancements offers a promising approach for enhancing therapeutic outcomes.

Recent developments in nanotechnology have introduced nano-carrier systems that improve the delivery of nutrients and therapeutic agents by enhancing bioavailability, enabling controlled release, and facilitating targeted action within the gastrointestinal tract[2]. In this context, the incorporation of hybrid protein–carbohydrate nano-carriers derived from rice into rice-based ORS represents an innovative strategy.

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Pathogenesis and Therapeutic Link

Rotavirus primarily infects mature enterocytes of the small intestine, leading to disruption of intestinal architecture and function. The virus enters host cells through receptor-mediated endocytosis and replicates intracellularly, resulting in destruction of absorptive epithelial cells and villous atrophy, which causes malabsorption and osmotic diarrhoea[3]. In addition, the viral non-structural protein NSP4 acts as an enterotoxin by increasing intracellular calcium levels and stimulating chloride ion secretion, leading to secretory diarrhoea and significant fluid loss [5]. These combined mechanisms result in severe dehydration, electrolyte imbalance, and impaired nutrient absorption.

In this context, oral rehydration therapy plays a crucial role by enhancing sodium and water absorption through glucose-coupled transport mechanisms[5]. Rice-based ORS offers additional advantages due to its complex carbohydrates, which provide sustained glucose release and improve electrolyte uptake while reducing stool output[6]. Furthermore, rice-derived components possess bioactive compounds that may support intestinal healing and reduce oxidative stress [7].

The incorporation of hybrid protein–carbohydrate nano-carriers into rice-based ORS further addresses the underlying pathophysiology of rotavirus infection. These nano-carriers enhance bioavailability, enable controlled electrolyte release, and facilitate targeted delivery within the gastrointestinal tract, thereby improving therapeutic efficiency [2,8].

Rice ORS *(Nerpori Kanji)*

நெற்பொரி

நெல்லைப் பொரித்து உமி போக்கி எடுத்து, கஞ்சி காய்ச்சி நோயாளிகளுக்கும் கொடுக்கலாம். முக்கியமாய் வயிற்று நோய், வெள்ளை, நீர்ச்சுருக்கு, சுரம் முதலிய நோயாளருக்கு இது வன்மைதரும். நீர்வேட்கை, வமனம், மந்தம், பெருவயிறு, கழிச்சல், சுவையின்மை முதலிய நோய்களும், மூர்ச்சையும் நீங்கும்.

நெற்பொரியைத் தின்றால் நெடுந்தாகம் வாந்திமந்தம்
மற்பித்த வாதமத மூர்ச்சை-பற்பலவாம்
பேதி யருசியிவை பேருலகை விட்டொழியுஞ்
சாதி மடமயிலே சாற்று. (அ.கு.)

The Siddha text describes *Nerpori Kanji* (popped rice gruel) as a therapeutic preparation beneficial in conditions such as diarrhoea, vomiting, dehydration, and digestive disturbances. It is indicated for restoring fluid balance, improving digestion, and alleviating symptoms like thirst, fatigue, and gastrointestinal discomfort. The preparation is also considered to enhance strength and support recovery in weakened individuals, particularly in paediatric and gastrointestinal disorders.

Preparation of *Nerpori Kanji* (Rice-Based ORS)

Nerpori Kanji (popped rice gruel) is prepared using popped rice as the primary ingredient. Initially, the popped rice containing bran is lightly dry roasted to enhance flavour and remove excess moisture. The bran is then separated as required.

A measured quantity of the processed popped rice is added to water and boiled until the grains soften, settle, and begin to disintegrate, forming a semi-liquid gruel. The mixture is then gently mashed to ensure uniform consistency.

After adequate boiling, the preparation is filtered to obtain a clear liquid. The filtrate is allowed to cool to a lukewarm temperature before administration.

The prepared *Kanji* can be consumed as needed or administered at regular intervals, typically once every hour, especially in conditions of dehydration and gastrointestinal disturbances.

Advanced Rice-Based ORS: An Overview

Rice-based oral rehydration solution (ORS) is an effective alternative to conventional glucose-based ORS, primarily designed to restore fluid and electrolyte balance in diarrheal conditions by enhancing sodium and water absorption through glucose-mediated co-transport mechanisms[5]. Unlike simple glucose solutions, rice-based ORS contains complex carbohydrates that undergo gradual digestion, resulting in sustained glucose release, improved electrolyte absorption, reduced stool output, and shorter duration of diarrhoea [3,6].

The use of popped rice *(Nerpori)* further enhances the functional properties of the formulation. The puffing process induces partial pre-gelatinization of starch, improving solubility, digestibility, and dispersion in aqueous media. This facilitates efficient intestinal absorption while maintaining low viscosity, which improves palatability and fluid intake, especially in paediatric patients. Thermal processing also reduces anti-nutritional factors, thereby enhancing mineral bioavailability [7].

Beyond rehydration, rice-based ORS may contribute to intestinal recovery. Fermentation of rice-derived carbohydrates by gut microbiota produces short-chain fatty acids (SCFAs), which support intestinal epithelial integrity and may modulate inflammatory responses. Additionally, rice bran contains bioactive compounds such as phenolics, γ-oryzanol, and tocopherols that exhibit antioxidant and gut-protective properties[7]. These effects may help restore gut homeostasis and improve overall gastrointestinal function during diarrhoeal illness.

Integration of rice-based ORS with hybrid protein–carbohydrate nano-carrier systems represent an advanced therapeutic approach. Such systems enhance bioavailability, enable controlled release of electrolytes and nutrients, and improve stability and delivery within the gastrointestinal tract[2,8,9]. These properties make nano-carriers highly suitable for improving the functional performance of oral rehydration formulations.

Overall, advanced rice-based ORS offers combined benefits of effective rehydration, nutritional support, and gut protection. Its cost-effectiveness, biocompatibility, and alignment with traditional dietary practices make it a promising approach for improved management of rotavirus-induced diarrhoea.

Popped rice is chosen for rice-based ORS because of its unique physicochemical properties that enhance the efficacy of oral rehydration therapy. Here are the key reasons:

Popped rice *(Nerpori)* is considered an effective carbohydrate source for rice-based oral rehydration solutions due to its favourable physicochemical and functional properties. The puffing process disrupts the native structure of rice starch, resulting in partial pre-gelatinization, which enhances solubility, digestibility, and rapid dispersion in aqueous media, thereby facilitating efficient intestinal absorption [3,5].

The increased availability of amylopectin, a highly branched starch, supports gradual glucose release, promoting sustained sodium and water absorption through intestinal co-transport mechanisms [3]. In addition, thermal processing during puffing reduces anti-nutritional factors such as phytic acid, improving mineral bioavailability and electrolyte utilization [7].

Popped rice also produces a low-viscosity solution compared to raw rice, allowing better fluid flow and minimizing gastric discomfort. Its mild taste enhances palatability, particularly in paediatric patients, thereby improving compliance during treatment[4]. Furthermore, the enhanced digestibility of pre-gelatinized starch makes it suitable for individuals with compromised gastrointestinal function, such as those suffering from diarrhoeal diseases [6].

Overall, these properties make popped rice a suitable and efficient component of rice-based ORS, contributing to improved hydration, electrolyte absorption, and patient acceptability during diarrhoeal management.

Potential Ways Rice ORS Could Impact the Gut-Brain Axis

Rice-based oral rehydration solution (ORS), while primarily intended for the management of dehydration, may exert indirect effects on the gut–brain axis through its influence on intestinal physiology and microbiota. The gut–brain axis represents a bidirectional communication network linking the gastrointestinal system and the central nervous system, mediated by neural, hormonal, and immunological pathways.

Restoration of fluid and electrolyte balance by rice-based ORS helps normalize intestinal function and may reduce gut inflammation associated with diarrhoeal diseases [5]. Improved hydration status is also known to support cognitive function and overall physiological stability. Additionally, the gradual digestion of complex carbohydrates in rice-based ORS promotes a more stable intestinal environment compared to simple glucose solutions [3].

Fermentation of rice-derived carbohydrates by gut microbiota can lead to the production of short-chain fatty acids (SCFAs), such as butyrate, propionate, and acetate. These metabolites play a key role in maintaining intestinal barrier integrity and may influence neurochemical pathways, including neurotransmitter synthesis and modulation of inflammatory responses. SCFAs have also been shown to interact with the gut–brain axis by affecting signalling pathways between the gut and central nervous system.

Furthermore, maintenance of gut microbiota balance during diarrhoeal episodes may support the production of neuroactive compounds such as gamma-aminobutyric acid (GABA), which is associated with regulation of stress and neuronal excitability. By supporting intestinal health and reducing inflammation, rice-based ORS may indirectly contribute to improved gut–brain communication.

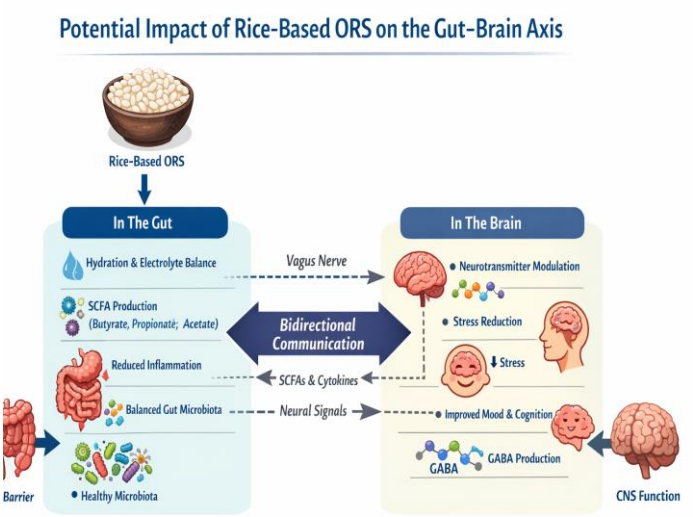

Fig 1: The potential impact of rice-based ORS on the gut–brain axis [10]

Overall, although the primary role of rice-based ORS is rehydration, its effects on gut microbiota, intestinal integrity, and metabolic activity suggest a potential supportive role in modulating the gut–brain axis. However, further experimental and clinical studies are required to substantiate these effects.

Traditional indication of Rice-Ors in following conditions

- Lactose intolerance
- Syncope and dizziness
- Leucorrhoea
- Ascites (fluid accumulation in the abdomen)
- Vomiting
- Ageusia

Why Rice ORS is Better Than Other?

- **Sustained glucose release**

  Rice contains complex carbohydrates that are digested slowly, providing gradual glucose release and sustained sodium–water absorption in the intestine [3,5].

- **Improved fluid absorption**

  The glucose–sodium co-transport mechanism is more efficient with rice-based substrates, enhancing rehydration effectiveness [5].

- **Reduced stool output**
  Clinical studies show rice-based ORS can reduce stool volume by approximately 20% compared to glucose-based ORS [4].
- **Shorter duration of diarrhoea**
  Improved absorption and reduced intestinal secretion contribute to faster recovery [6].
- **Lower effective osmolarity**
  Rice-based ORS provides complex carbohydrates with lower osmotic load, reducing the risk of osmotic diarrhoea [3].
- **Supports intestinal healing**
  Rice bran contains bioactive compounds (phenolics, γ-oryzanol, tocopherols) that exhibit antioxidant and mucosal protective effects [7].
- **Prebiotic potential:** Rice carbohydrates can be fermented by gut microbiota to produce short-chain fatty acids (SCFAs), supporting gut integrity and function.
- **Better tolerance and palatability**
  Popped rice formulations improve digestibility and are well accepted, especially in paediatric patients[7].
- **Nutritional advantage**
  Provides additional nutrients beyond simple glucose-based ORS, including small amounts of protein and micronutrients [7].
- **Cost-effective and accessible**
  Can be prepared locally using rice, making it suitable for low-resource settings.
- **Dual action (rehydration + reduced fluid loss)**
  Rice-based ORS not only replaces fluids but also reduces ongoing diarrhoeal losses. [5]

Notable Rice-Based ORS Products

1. Cera Lyte

- A clinically tested rice-based oral rehydration solution.
- Uses patented rice-derived carbohydrates for enhanced electrolyte absorption.
- Demonstrated ability to reduce fluid loss and improve hydration efficiency.
- Available in different formulations (CeraLyte 50, 70, 90) based on severity of dehydration.

2. Cera Sport

- A rice-based electrolyte solution designed for hydration and recovery.
- Uses the same rice carbohydrate technology but optimized for milder dehydration and energy balance.
- Helps maintain fluid and electrolyte balance during stress or illness.

3. Pre-packaged Rice-Based ORS (e.g., CeraLyte clinical formulations)

- Developed for clinical use and widely used in hospitals and field settings.
- Proven effective in treating severe diarrhoeal diseases like cholera.
- Shown to outperform glucose-based ORS in early-phase diarrhoea management.

DISCUSSION

Rotavirus-induced diarrhoea is a major cause of dehydration in children, where oral rehydration solution (ORS) remains the cornerstone of management. Conventional glucose-based ORS restores fluid and electrolyte balance through sodium–glucose co-transport but has limited impact on intestinal recovery[5]. Rice-based ORS offers advantages due to its complex carbohydrates, which provide sustained glucose release, enhance sodium and water absorption, and reduce stool output and duration of diarrhoea[3,6]. Clinical evidence also indicates improved hydration outcomes with rice-based formulations compared to standard ORS [4].

Additionally, rice-derived bioactive compounds exhibit antioxidant and anti-inflammatory properties that may support intestinal healing[7]. The incorporation of hybrid protein–carbohydrate nano-carriers further enhances the therapeutic potential of rice-based ORS by improving bioavailability, enabling controlled release of electrolytes and nutrients, and facilitating targeted delivery within the gastrointestinal tract [2,8,9].

Overall, this integrative approach combines effective rehydration with gut protection. However, further in vivo and clinical studies are required to validate its efficacy in rotavirus management.

CONCLUSION

Rice-based oral rehydration solution (ORS) represents an effective alternative to conventional glucose-based formulations by providing sustained glucose release, improved electrolyte absorption, and reduced diarrhoeal severity. The incorporation of hybrid protein–carbohydrate nano-carriers further enhances its therapeutic potential by enabling controlled nutrient delivery, improved bioavailability, and targeted intestinal action. This integrative approach not only addresses dehydration but also supports intestinal recovery and gut health during rotavirus infection.

Overall, the developed formulation demonstrates promise as a cost-effective, biocompatible, and advanced strategy for managing rotavirus-induced diarrhoea, particularly in paediatric populations. However, further in vivo studies and clinical trials are necessary to validate its efficacy and feasibility for large-scale application.

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