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Research Article

Formulation and Evaluation of Monk Fruit Extract-Based Zero-Calorie Electrolyte Replenisher Powder: A Novel Functional Formulation

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Abstract

The present study aims to develop and evaluate a natural, zero-calorie electrolyte replenisher formulated using monk fruit extract (Siraitia grosvenorii) as a non-glycemic sweetener. Considering the increasing prevalence of diabetes, obesity, and excessive sugar consumption, this formulation provides a healthier alternative to conventional sugar-based oral rehydration products. A WHO ORS–derived electrolyte composition containing sodium chloride, potassium chloride, trisodium citrate, citric acid, and monk fruit extract was prepared by dry blending and packed in moisture-proof sachets. Physicochemical evaluation demonstrated favorable organoleptic properties, rapid solubility (28 ± 2 s), slightly acidic pH (6.5 ± 0.1), and low moisture content (2.1%), indicating good initial quality. Accelerated stability testing at 40°C/75% RH for 28 days showed a gradual increase in moisture content (up to 3.5%) and mild caking, while pH remained stable (6.4–6.5), confirming the absence of chemical degradation. The results suggest that the formulation is primarily affected by hygroscopicity and requires strong moisture-proof packaging for extended shelf life. Overall, the study demonstrates that monk fruit–sweetened electrolyte powder is a viable, stable, and clean-label alternative suitable for diabetics, ketogenic users, athletes, and general consumers seeking natural, zero-calorie hydration solutions. Further sensory and clinical studies are recommended to optimize taste and validate rehydration efficacy.

Keywords: Monk fruit; Mogrosides; Zero-calorie natural sweetener; Electrolyte replenisher; Hydration therapy; Diabetes-friendly formulation.

INTRODUCTION:

Maintaining physiological function requires electrolyte balance and proper hydration, particularly in individuals with diabetes and those who are physically fit. Blood sugar levels may rise as a result of the glucose or sucrose used as carbohydrate sources in traditional oral rehydration solutions (ORS) and electrolyte drinks. Monk fruit (Siraitia grosvenorii), a natural non-caloric sweetener, is a possible substitute because of its potent sweetness, stability, and bioactive qualities. Siraitia grosvenorii is a species of the genus Siraitia Merr. (Cucurbitaceae) native to southern China, primarily Guangxi Province. This genus has seven species, four of which are native to China, and two of which have therapeutic properties. The formal Chinese name for S. grosvenorii is luo han guo (Chinese: 罗汉果), and it is locally known as lahanguo, jiakugua, changshouguo. [1] In contrast to artificial sweeteners, monk fruit extract has been deemed generally recognized as safe (GRAS) by the FDA and further demonstrates pharmacological actions such as hepatoprotective, anti-inflammatory, and anti-diabetic properties. The fruit has long been used as a natural zero calorie food sweetener and as a home medicine for sunstroke, severe thirst, constipation, colds, coughs, sore throats, and lung nourishment.[2] Calorie consumption is strongly linked to obesity which is rapidly growing in India as a result of high sugar intake and availability of high fat, energy-dense foods, as well as a decrease in energy expenditure due to urbanization and automation. In India, the frequency of metabolic syndrome and type 2 diabetes mellitus (T2DM) is on the increase, reaching epidemic proportions. India has around 65 million diabetics, second only to China globally.[3] Consuming too much sugar can lead to obesity, which is a risk factor for type 2 diabetes. Dietary sugar intake, particularly fructose and sugar-sweetened beverages, may increase the risk of T2D through glycemic effects independent of overweight and obesity, such as increased liver fat content or specific adipose tissues.[4] This study addresses a market gap by recommending a formulation that combines the WHO ORS's verified electrolyte balance with monk fruit extract's natural, zero-calorie sweetening qualities. The primary goal was to create a stable powder with a WHO-ORS-based electrolyte profile and monk fruit extract for diabetics and health-conscious people, then analyse its basic evaluation and short-term stability using simple, accessible methodologies.

Monk Fruit Extract as an Ideal Sweetener:

Biochemical Basis of Sweetness:

Luo han guo extract contains mogrosides, a type of triterpene glycoside found in about 1% of the fruit's flesh. These compounds impart a sweet flavor to luo han guo. In general, five distinct mogrosides have been identified from these fruits and assigned the numbers I to V. Mogroside V (previously known as esgosid) is the most abundant mogroside of the five. As a result, it determines the sweetness and quality of luo han guo. A prior study discovered that the sweetness of mixed mogrosides can be around 300 times that of sugar by weight while containing zero calories, whereas sugar provides approximately 4.5kcal/g. As a result, luo han guo extract is commonly utilized as a sweetener in drinks and cooked meals. Luo han guo extract contains comparable chemicals such as siamenoside and neomogroside.[5] According to pharmacological research, mogrosides have strong antioxidant and anti-diabetic properties. For example, mogroside (MGE) demonstrated significant hypoglycemia and hypolipidemic effects in a research employing a high-fat diet and a streptozotocin (STZ)-induced diabetes animal. These effects were linked to the stimulation of the liver's AMP-activated protein kinase (AMPK) signaling pathway [6]. Moreover, mogrosides have been demonstrated to raise antioxidant enzyme activity and lower lipid peroxide levels in vivo, highlighting their critical function in the antioxidant defense system. With a temporal profile more similar to sucrose, mogrosides offer a clean, sweet taste in contrast to other natural high-intensity sweeteners like stevia, which can have a strong bitter or licorice-like aftertaste because of steviol glycosides. Compared to stevia, any remaining aftertaste is far less unpleasant and is sometimes described as fruity or licorice-like. This makes it simpler to hide in finished compositions.[7]

Table 1: Rationale- Monk Fruit Sweetener VS Sugar in electrolyte Replenisher:

Sr. No.	Aspect	Why Monk Fruit Sweetener is better
1.	Glycemic Impact	Zero glycemic index; does not raise blood sugar or insulin levels, unlike sugar-based ORS.[8]
2.	Caloric Content	Contributes zero calories, beneficial for weight management and reducing empty calorie intake.[9]
3.	Composition & Effects	Contains mogrosides (antioxidants with potential anti-inflammatory effects), unlike nutritive sugars .[9]
4.	Dental Health	Non-cariogenic; does not promote tooth decay, whereas sugars contribute.[10]
5.	Regulatory Status	Generally Recognized As Safe (GRAS) by the U.S. FDA and other international food safety authorities .[11]

Table 2: Sweetness profile, benefits and health risks of some artificial and natural sweeteners:

Name	Comparison with sucrose	Health Benefits	Health risks
Aspartame [12]	170 times	Low calorie Sweetener	Its consumption may be linked to obesity, glucose intolerance, mood disorders, pre-mature birth, neurodegenerative effects.
Sucralose [12]	200 times	Low calorie Sweetener	Its consumption may be linked to metabolic syndrome, type 2 diabetes, hypertension, obesity and potential carcinogenic effect
Stevia [10]	1. rebaudioside A is 150–320 times 2. stevioside is 100–270 times	Antioxidant, antibacterial, chemotherapeutic, immunemo-dulating properties, helps in weight management by reducing appetite	No known side effects but stevia may leave a slightly bitter or metallic aftertaste due to stevioside, while rebaudioside A is reported to lack this aftertaste
Monk fruit [13]	~100 -250 times	Antioxidant, Anti-inflammatory, anti-obese, anti-carcinogenic and anti-diabetic	No known side-effects

MATERIALS:

Table 3: Formulation Composition of Monk Fruit-Based Zero-Calorie Electrolyte Replenisher based on WHO ORS formula (per 1 Litre): [14]

Sr. No.	Ingredients	Quantity (g/L)	Quantity per serving (250ml)	Role
1.	Sodium chloride (NaCl)	2.6 g	0.70g	Restores Na &Cl
2.	Pottasium Chloride (kcl)	1.5g	0.40g	Restores potassium ion
3.	Trisodium citrate dihydrate ($Na_3C_6H_5O_7$·	2.9g	0.75g	Buffer to correct metabolic acidosis
4.	Citric Acid	0.28g	0.07g	pH balance, add flavour
5.	Monk fruit powder (25% Mogroside V)	0.125g	0.03g	Natural zero calorie sweetener
Total		~7.5g	~2g	

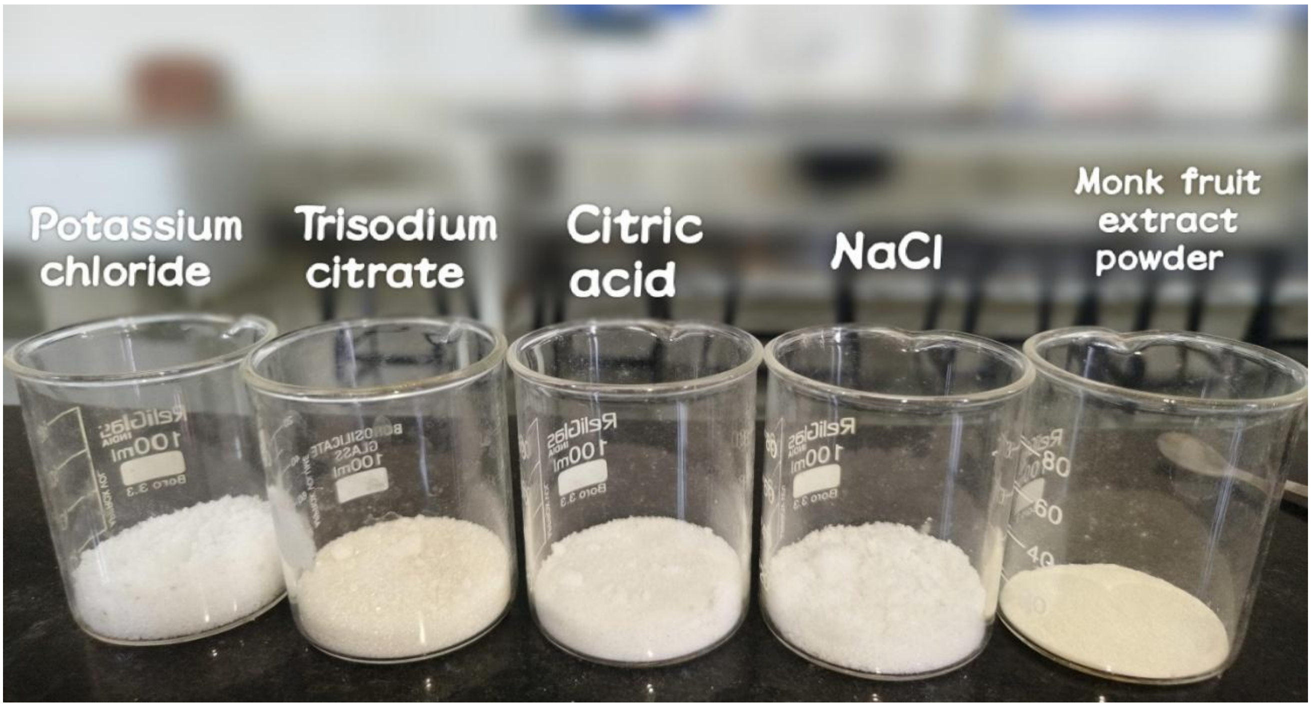


Figure 1: Composition of Zero-Calorie Electrolyte Replenisher

METHODOLOGY:

Accurate Weighing of all ingredients (NaCl, KCl, Trisodium citrate, Monk fruit extract)
↓
Sieving each ingredient through #60 mesh to remove lumps
↓
Dry mixing of electrolytes (NaCl + KCl + Trisodium citrate) for 5–10 minutes
↓
Addition of Monk Fruit Extract to the pre-mix
↓
Gentle blending for 10–15 minutes to ensure uniform distribution
↓
Packing of ~7.5 g blended powder into moisture-proof laminated sachets
↓
Sealing, labeling, and storage in cool, dry conditions

Figure 2: Electrolyte Replenisher Powder Packed in Self Sealing Moisture Proof Sachet And stored in container

Figure 3: Label for Electrolyte Replenisher Powder (HydraZero) Prepared for Understanding

EVALUATION PARAMETERS:

Organoleptic Characteristics:

To evaluate the powder's sensory and visual qualities, which are crucial for consumer approval. It includes –

1. Colour: A tiny amount of the powder was set on a white surface and examined under constant, daylight-equivalent lighting. Standard terminology (such as white, off-white, and creamy white) were used to characterize the colour.
2. Odour: The powder was smelled immediately after opening the container. The smell was characterized as either non-existent, distinctive, or lacking any particular aroma (e.g., mildly fruity).
3. Texture and Flowability: The powder's texture (e.g., smooth, grainy) was evaluated by pressing it between fingers. Pouring the powder from a glass beaker allowed for a qualitative evaluation of flowability, which was classified as cohesive, free-flowing, or poor-flowing.

Solubility:

The purpose of this experiment is to determine how long it takes for the powder to completely dissolve in water, which is an important functional property for a rehydration product.
Procedure (Stirring Method):

250 mL distilled water was measured into a 400 mL glass beaker and kept at 25°C ± 2°C using a water bath.

↓

A 5.0 g quantity of electrolyte powder was weighed precisely.

↓

A magnetic stirrer was adjusted at a consistent, moderate speed of 300 rpm.

↓

Powder was added to the water, and a timer was started simultaneously.

↓

The time it took for all visible particles to disintegrate entirely was recorded. The endpoint was defined as the moment at which no particles could be seen on the beaker walls or in the solution under visual inspection.

pH of the Reconstituted Solution:

Purpose: To determine the acidity or alkalinity of the finished drink, which affects palatability, stability, and digestive compatibility.

Procedure:

1.A 5% w/v solution was created by dissolving 5.0 g of the powder in 100 mL of distilled water.

↓

2. A calibrated digital pH metre was utilized. The electrode was thoroughly washed with distilled water before being immersed in the prepared solution.

↓

3.After allowing the reading to stabilize for around 30-60 seconds, the pH was recorded

Content of Moisture:

The goal is to ascertain how much water is in the powder. For powder stability and to stop microbiological growth, low moisture content is crucial.

Method (Hot Air Oven Method for Loss on Drying):

For thirty minutes, a dry, clean glass petri dish was heated to 105°C in a hot air oven. After that, it was sent to a desiccator to cool.

↓

The empty, cooled petri dish's weight was noted as W1

↓

The petri dish was filled with two to three grams of the powder sample, and the total weight was precisely noted as W2.

↓

For three hours, the petri dish containing the material was kept at 105°C in the hot air oven.

↓

The dish was moved to a desiccator after three hours, allowed to cool to ambient temperature, and then promptly weighed. W3 was noted for this weight.

The formula for calculating moisture content was as follows:

$$\text{Moisture Content (\%)} = [(W2 - W3) / (W2 - W1)] \times 100$$

Hygroscopicity:

The purpose of hygroscopicity is to assess the powder's propensity to collect moisture from the atmosphere, which has a direct impact on its shelf life and physical stability.

Method:

An excess of sodium chloride (NaCl) was added to distilled water in a desiccator to create a saturated salt solution. As a result, a steady relative humidity (RH) of roughly 75% is produced.

↓

A shallow glass dish that had been previously weighed was filled with precisely 2.0 g of the powder (Wi).

↓

To prevent it from coming into contact with the salt solution, the dish (without the lid) was put inside the desiccator.

↓

The desiccator was sealed and kept for a week (7 days) at room temperature, such as 25°C.

↓

The dish was taken out after a week and weighed right away to determine the ultimate weight (Wf).

$$\text{Hygroscopicity (\%)} = [(Wf - Wi) / Wi] \times 100$$

Accelerated Stability:

The goal is to use stress circumstances to forecast the powder's physical stability and shelf life.

Method:

1. Packaging: A sealed low-density polyethylene (LDPE) sachets (which simulate single-serve packets) were the two main packaging options used to package the powder for comparison.

↓

2. Storage Conditions: For 28 days, the packaged samples were kept in a controlled environment incubator at 40°C ± 2°C and 75% ± 5% relative humidity. To maintain the necessary humidity, a saturated NaCl solution was added to the incubator.

↓

3. Sampling and Analysis: At pre-arranged intervals of 0, 7, 14, 21, and 28 days, samples were taken out and examined for the following:

- Visual Appearance & Caking: Any colour shift, lump formation, or hardening were noted.
- A semi-quantitative rating system was used for caking:

1 = Free-flowing

2 = A little clumped (breaks when tapped)

3 = Moderately caked (breaks under light pressure)

4 = Hard caked, requiring a lot of force to crack

5 = a solid mass.

Moisture Content: Examined utilizing the previously mentioned Loss on Drying technique.

pH: The pH of the reconstituted solution was measured as per section mentioned above.

Solubility: After the 28-day period, the solubility time was measured.

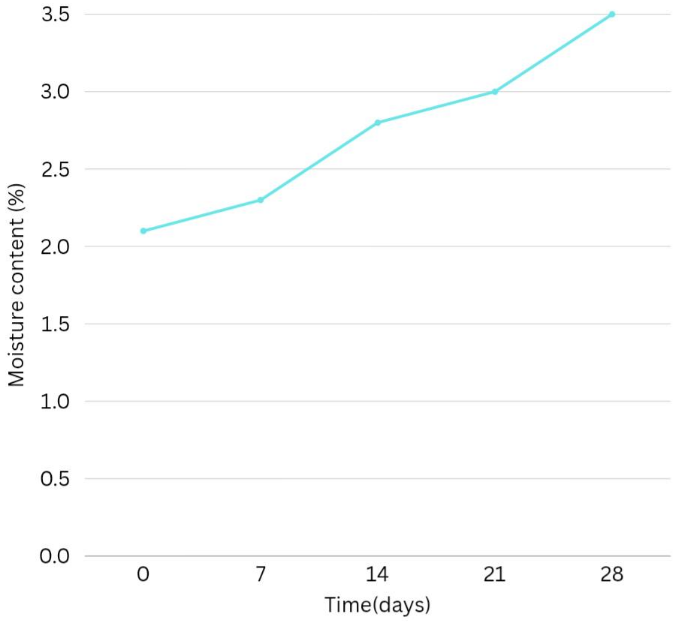
RESULTS:

Table 4: Initial Physicochemical Evaluation of the Electrolyte Powder

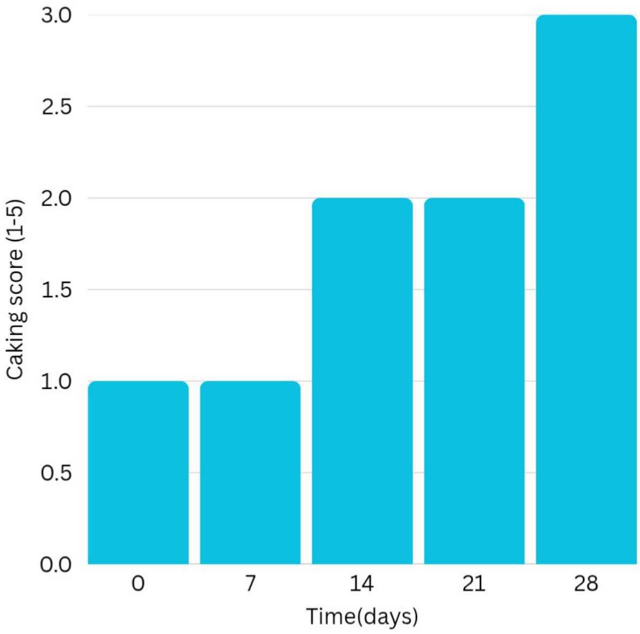
Parameters	Results (means ±SD)	Observation
Organoleptic Properties	White, free-flowing powder	The product was visually appealing and easy to handle.
Solubility Time (seconds)	28 ± 2	Indicates rapid dissolution, a desirable characteristic.
pH (5% solution)	6.5 ± 0.1	Slightly acidic pH, which is palatable and can enhance stability.
Moisture Content (%)	2.1 ± 0.3	Low initial moisture, favourable for microbial and chemical stability.
Hygroscopicity (% weight gain)	4.5 ± 0.5	Moderate; suggests a need for moisture-proof packaging.

Table 5: Accelerated Stability Data of Electrolyte Powder Stored in Single Use Sachets at 40°C/75% RH

Time (Days)	Caking Score (1-5)	Moisture Content (%)	pH	Solubility Time (sec)
0	1	2.1	6.5	28
7	1	2.3	6.5	29
14	2	2.8	6.4	32
21	2	3	6.4	35
28	3	3.5	6.4	36



Graph 1: Change in Moisture Content of Electrolyte Powder under Accelerated Storage conditions



Graph 2: Change in Caking Score of Electrolyte Powder under Accelerated Storage Conditions.

DISCUSSION:

The monk fruit extract-sweetened electrolyte powder was effectively formulated, resulting in a homogeneous, free-flowing product. Initial examination confirmed favourable qualities, with an initial solubility time of 28 seconds, a pH of 6.5 and moisture content of 2.1%.

Accelerated stability testing over 28 days at 40°C/75% RH provided critical insights into the product's behaviour. Moisture content exhibited a time-dependent increase, rising from an initial 2.1% to 3.5% in sachets (Graph1). This moisture uptake directly correlated with a progressive increase in caking scores, the electrolyte replenisher shows slight clumping over accelerated study (Graph 2). Consequently, the solubility time for these samples increased to over 36 seconds. In contrast, the pH of the reconstituted solution remained stable between 6.4 and 6.5, indicating no significant chemical degradation. The superior performance of sachet packaging highlights its necessity for maintaining product quality. The primary observed change was a physical one: a gradual increase in moisture content and minor caking in the final week, directly linked to the hygroscopic nature of the ingredients. This confirms that the key to shelf-life is robust, moisture-proof packaging rather than ingredient degradation. The study successfully demonstrates that a viable, stable, zero-calorie electrolyte powder can be produced using monk fruit extract, with its stability primarily dependent on controlling environmental humidity.

It can be concluded that the monk fruit-sweetened electrolyte powder is physically stable for a projected three-month shelf-life when stored in moisture-proof, single-serve packaging. Future work should focus on further enhancing stability.

CONCLUSION:

This study successfully developed and evaluated a novel zero-calorie electrolyte replenishment powder utilizing monk fruit extract as the primary sweetener. The formulation, based on a WHO ORS-inspired electrolyte profile, demonstrated excellent initial characteristics and satisfactory short-term stability when protected from moisture. This product directly addresses a significant gap in the market for specialized hydration. For individuals managing diabetes, it provides effective rehydration without impacting blood glucose levels, thanks to the non-glycemic mogrosides in monk fruit. For those following ketogenic or low-carb diets, it offers crucial electrolyte support without the carb-loaded sugars that can disrupt ketosis. Furthermore, it aligns with the growing demand from general health-conscious consumers for clean-label, naturally sweetened functional products. Thus, this formulation presents a viable, scientifically grounded alternative to conventional sugary or artificially sweetened sports drinks, promoting accessible wellness without dietary compromise. Future research involving sensory analysis and clinical efficacy trials is recommended to optimize palatability and validate physiological benefits.

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