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# SPIRULINA AS A NUTRITIONAL SUPPLEMENT FOR ENTERAL FEEDING IN INTENSIVE CARE PATIENTS: A PILOT STUDY

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**Abstract:**
Intensive Care Unit (ICU) trauma patients are having trouble with food consumption, and due to a lack of nutrition, their recovery slows down. To improve the recovery of critically ill patients, dietary supplements have to be given externally. Such dietary supplement formulas are available on the market, but due to some limitations in nutritional values as well as preservatives, these products are not much more helpful for ICU patients' recovery. Hence, a good dietary supplement with a normal cost is demanded in the medical field. In this investigation, a dietary supplement containing wheat flour (*Triticum spp*.), rice (*Oryza sativa*), red gram (*Cicer arietinum*), green gram (*Vigna radiata*), milk powder, cardamom, cumin, dry ginger, along with *Spirulina* was evaluated. The preparation was supplemented with Spirulina for the critically ill and trauma patients in the ICU. Nutritional profiling of the dietary formula was carried out, in which protein, carbohydrates, fat, calcium, magnesium, iron, riboflavin, thiamine, and niacin and their energy contents per 100 grams were determined. To confirm the safety of the product, microbiological analysis was done, and the dietary supplement was found to be safe for consumption by ICU patients.

**Keywords**: ICU patients, Spirulina, Dietary Supplement, Nutritional Profiling, Microbiological Analysis

## 1. Introduction:

Nutrition in the form of carbohydrates, fats, proteins, and micronutrients is the basic constructive unit of life (Otten et al., 2006; Yetley, 2007). In some medical situations, like diseases, disorders, and trauma, patients in the intensive Care unit become weak enough that they can't consume the nutrients through regular food (Vanhorebeek et al., 2020). In ICU patients, nutrient supplementation is a big challenge for doctors and medical staff. To prevent further metabolic deterioration and loss of lean body mass in critically ill patients, nutrition supplements play an important role (Hoffer et al., 2014). A good dietary supplement helps in the recovery of ICU patients, which helps to decrease the patient's hospital stay, morbidity rate, and improvement in the outcome from the trauma (Samadi et al., 2016). Proper dietary supplements, including proteins, carbohydrates, healthy fats, vitamins, minerals, and other micronutrients, can increase the possibilities of recovery from trauma in critically ill patients, and early supplementation of these components can decrease the severity of trauma and disease, reduce complications and the risk of death, as well as minimise the stay in the ICU of the hospital (Patkova et al., 2017).

Spirulina is a nutritional supplement with vast clinical application in nutrition due to its food composition consisting of lipids, carbohydrates, hydrocarbons, sterols, proteins (containing various amino acids, including branched-chain amino acids), and many micronutrients such as vitamin B12, calcium, iron, folate, magnesium, manganese, potassium, selenium, and zinc (Belay et al., 2008; Cohen Z et al., 1997; Grosshagauer et al., 2020). In the present investigation, we have confirmed and documented its add-on effect in the nutritional supplement used for the ICU patients in RT feeding.

Feeding protocols for ICU patients are designed to provide protein intake in the range of 1.3g/kg in 24 hours (Kim et al., 2022). While providing a diet for ICU patients, the important factors considered are the route of nutritional support, nutritional access, fluid and electrolyte issues, and optimal glucose control. All these things can be controlled by nutritional assessment, nutritional diagnosis, nutrition intervention, nutrition monitoring, and nutrition evaluation. Adequate nutrition intervention has been shown to make the metabolic response to stress less effective and favourably create the desired effects on immune responses (De Cosmi et al., 2017).

Currently, several dietary food products are available in the pharmaceutical sector that are given to ICU patients. Still, these products are not fulfilling the desired requirements, and they contain preservatives that adversely affect patients' health (Mehta et al., 2018). Some products with the nutritional profile required for critically ill patients have a huge price tag that isn't affordable to the common sufferer. Hence, there was an urgent need for a dietary supplement made up of natural ingredients with a good nutritional profile, a longer shelf life, and affordability for common people. Therefore, in the present investigation, a spirulina-based dietary food supplement (Matondo et al., 2016) is prepared with all locally available natural ingredients, including wheat, rice, gram, milk powder, ginger, cumin, and cardamom. The process of preparation is very simple but effective for maintaining constant nutritional values, ease of digestibility, storage ability, and affordability.

## 2. Material and Methodology:

Raw materials required for the preparation of dietary supplements include *Triticum spp.* (Wheat flour), *Oryza sativa* (Rice), *Cicer arietinum (*red gram*), Vigna radiata (green gram),* milk powder, cardamom, cumin, and dry ginger procured from the local market of Nanded city, and spray-dried Spirulina powder obtained from Neoliva Lifescience Pvt. Ltd., Pune.

### *2.1. Process for Formulation of a Dietary Supplement:*

The process for preparing the dietary supplement contains four stages: soaking, drying, roasting, and grinding. All the grain ingredients were cleaned using a sieve to remove impurities and debris. All the raw materials, except Spirulina, were soaked in sterile distilled water for 24 hours, followed by drying in a shed. Then the mixture of all ingredients was proceeded to roast on medium flame to cook all the food material properly. Precaution is taken to prevent the overcooking of the materials. The roasted grains were ground in a sterile grinder to make a fine powder aseptically. Packed sterile milk powder and Spirulina powder were then added to the previously prepared grain powder in proper proportion. The prepared dietary supplement is then tested for its nutritional values.

### *2.2 Nutritional analysis of the dietary supplement:*

Prepared dietary supplements were checked for estimating the nutritional values, including protein (Lowry's method), carbohydrate (Anthrone method), fat (Soxhlet extraction method), Calcium, Iron, Riboflavin, Thiamin, niacin, and energy (KCl) per 100 g of dietary supplement.

### **2.3** *Microbiological analysis of the dietary supplement:*

The prepared dietary supplement is then sent for microbiological analysis to check the microbial load in the formula using the standard plate count method (Baig *et al.*, 2002). 1gm of homogenised dietary formula was added to 10 ml of sterile saline to make the suspension, and 0.1 ml of the suspension was spread on a pre-sterilised nutrient agar plate. After incubation, the plates were analysed for microbial

colonies. Morphological and microscopic features of the colonies were checked. All the experiments were done in triplicate .

## 3. Observations and Result:

### 3.1. *Nutritional valuation of dietary formula:*

The nutritional analysis and energy contents of the prepared dietary supplement formula are as per Table 1. Amongst the ingredients used in this supplement, Spirulina has shown the highest protein (57 g), riboflavin (3.670 mg), thiamin (2.380 mg), and niacin (12.8 mg) content. Rice has the highest carbohydrate content (78.2 g). Compared with others, powdered milk has the highest fat content (27 g). Cumin has the highest Ca (931 mg) and Iron content (66.36 mg). However, amongst all these components, powdered milk has the highest energy value, i.e., 496 Kcal/mol.

### *3.2. Effect of RT feeding on blood parameters in ICU patients*

The supplement has shown significant improvement in all the patients under study in Hb levels, which reveals the beneficial nutritional effect of this formula. It has also corrected serum creatinine levels in treated patients. It has significantly decreased the WBC levels in all the patients under study. Overall, the supplement has improved all the disease markers in the treated patients, which justifies its curative effect.

### *3.3. Microbiological analysis of the dietary supplement:*

No bacterial or fungal evidence was observed on the nutrient agar plate and Potato Dextrose agar plate, respectively.

## 4. Discussion and Conclusion:

ICU and Trauma patients are suffering from a deficiency of nutrients, which delays recovery from the trauma. In the early stages of trauma or critical illness, the daily nutritional requirements of patients are high. If such nutrients were given to the patients, it would enhance their response to treatment, increase their recovery, and decrease their hospital stay. Currently available ready-made packed nutrient supplement products are less effective if considered for all ICU patients. Instead, the dietary supplement is made up of natural ingredients, including Triticum spp. (Wheat flour), Oryza sativa (Rice), Cicer arietinum (Red gramme), Vigna radiata(green Gram), milk powder, cardamom, cumin, and dry ginger, with added Spirulina to enhance nutrition values. Laskowski et al. (2019) also explained the nutrition values of the dietary supplements depending on their composition. The addition of Spirulina to the dietary supplement formulation increases nutritional as well as energy values. Karkos et al. (2011) and Sharoba (2014) explained the importance of adding spirulina to dietary supplements.

Processing methods used in this research work include soaking, which decreases the anti-nutritional properties and detoxification, whereas drying, grinding, and roasting help in the homogenization of all ingredients and make them microbial contamination-free and digestible, respectively. Hence, processing the raw material of the dietary supplement formulation carries a significant role in value addition to the nutritional level because the ingredients used in the preparation of the dietary supplements have to be processed correctly to access their nutritional aspects (Vasishtha et al., 2013). The nutritional value of the dietary supplement determines the quality of the product. Because the more nutritious the product, the better it will help in the recovery of critically ill patients by fulfilling their body's requirements for nutrients. Energy contents are also an important parameter for dietary supplements, which provide the potential for ICU patients to fight against illness and reduce hospital stays. Shrestha et al. (2021) also evaluated the nutritional values of dietary supplements using standard protocols for different biomolecules and their energy contents (Shrestha et al., 2021). In the present study, our supplement has shown significant improvements in all the clinical parameters, which justifies its further recommendation as an RT feed for trauma patients in the ICU.

Microorganisms can contaminate food products, or bacterial contaminated food or their extracellular enzymes may affect the quality of the food (Kothari and Baig, 2013). This aspect becomes more sensitive especially in critically ill patients whose immunity is decreased, they cannot tolerate the secondary attack from the microorganism through dietary supplements. Hence, microbiological analysis is an essential step in the formulation of dietary supplements for ICU patients. In the present investigation, the dietary supplement was confirmed to be bacterial and fungal contamination-free, making it safe for consumption by critically ill and ICU patients. Ratajczak et al. (2015) and Vincenzina et al. (2022) also tested the dietary supplement formula for microbiological analysis. In the present research work, a dietary supplement with Spirulina formula was prepared that is high in nutrients, energetic, and free from contamination and can be used as a dietary supplement for critically ill patients in the ICU for better recovery from illness. Further characteristics of the dietary formula are still in progress.

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**Table.1 Nutritional valuation of dietary supplement formula**

| Sr. No | Ingredients | Nutrients/100gm of dietary supplement formula | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Protein | Carbohydrates | Fat | Ca | Iron | Riboflavin | Thiamin | Niacin | Energy (KCl) |
| 1 | Wheat | 11.8g | 71.2g | 1.5g | 41.0mg | 5.3mg | 0.17mg | 0.45mg | 5.5mg | 346 |
| 2 | Rice | 13.7g | 78.2g | 0.5g | 10.0mg | 0.7mg | 0.06mg | 0.06mg | 1.9mg | 345 |
| 3 | Green Gram Dal | 24.5g | 59.9g | 1.2g | 75.0mg | 3.9mg | 0.21mg | 0.47mg | 2.4mg | 348 |
| 4 | Red Gram Dal | 22.3g | 57.6g | 1.7g | 73.0mg | 2.7mg | 0.19mg | 0.45mg | 2.9mg | 335 |
| 5 | Bengal Gram Dal | 20.8g | 59.8g | 5.6g | 56.0mg | 5.3mg | 0.18mg | 0.48mg | 2.4mg | 372 |
| 6 | Spirulina | 57.0g | 24.0g | 8.0g | 120 mg | 29.0 mg | 3.670 mg | 2.38mg | 12.8 mg | 290 |
| 7 | Cardamom | 11.0g | 68.0g | 7.0g | 383 mg | 14.0mg | 0.182 mg | 0.198mg | 1.10 mg | 311 |
| 8 | Powdered milk | 26.0g | 38.0g | 27.0g | 912 mg | 0.47 mg | - | - | - | 496 |
| 9 | Cumin | 18.0g | 44.0g | 22.0g | 931mg | 66.36mg | 0.33mg | 0.63mg | 4.58mg | 375 |
| 10 | Dry Ginger | 9.12g | 70.79g | 5.95g | 116mg | 11.52mg | 0.185mg | 0.046mg | 5.155mg | 347 |

**Table.2: Effect of RT feeding on blood parameters in ICU patients**

| Patient No | Age | Gender | Hb | | Total WBC | | Na | | K | | Ca | | Blood Urea | | Serum Creatine | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Before | After | Before | After | Before | After | Before | After | Before | After | Before | After | Before | After |
| 1 | 55 | M | 12.8 | 13.2 | 10200 | 9400 | 130 | 134 | 4.1 | 4 | 5.2 | 4.28 | 46 | 22 | 1.22 | 0.62 |
| 2 | 61 | M | 13.5 | 14.1 | 15800 | 11300 | 133 | 138 | 4.6 | 3.9 | 5.16 | 4.69 | 27 | 16 | 1.02 | 0.7 |
| 3 | 59 | M | 9.8 | 10.2 | 11000 | 7600 | 130 | 136 | 4.4 | 3.6 | 4.0 | 4.09 | 48 | 27 | 1.94 | 0.95 |
| 4 | 62 | M | 11.8 | 13.9 | 15900 | 13200 | 120 | 135 | 3.3 | 4.4 | 4.05 | 5.01 | 35 | 24 | 1.16 | 0.94 |
| 5 | 52 | M | 11.8 | 13.9 | 13200 | 11800 | 122 | 136 | 3.2 | 3.5 | 4.2 | 5.01 | 36 | 16 | 1.16 | 0.89 |
| 6 | 53 | M | 13.1 | 14.1 | 11000 | 8700 | 114 | 142 | 2.4 | 3.1 | 4.8 | 5.18 | 32 | 18 | 1.88 | 0.82 |
| 7 | 58 | M | 12.5 | 13.8 | 10000 | 8500 | 122 | 138 | 4.24 | 4.48 | 4.98 | 5.18 | 46 | 22 | 1.42 | 0.86 |
| 8 | 62 | M | 11.6 | 12.9 | 15400 | 10300 | 129 | 136 | 3.1 | 3.6 | 4.4 | 5.3 | 78 | 28 | 1.98 | 0.46 |
| 9 | 60 | M | 11.8 | 12.6 | 13800 | 9800 | 128 | 136 | 3.3 | 3.8 | 4.2 | 5.2 | 58 | 23 | 2.12 | 0.98 |
| 10 | 54 | M | 10.3 | 13.5 | 21100 | 10200 | 135 | 138 | 3.4 | 3.7 | 4.79 | 5.19 | 58 | 22 | 1.98 | 0.8 |
| 11 | 58 | M | 10.7 | 12.5 | 13800 | 8700 | 144 | 138 | 4.8 | 3.3 | 4.9 | 5.2 | 48 | 24 | 1.82 | 0.78 |
| 12 | 52 | M | 11.6 | 12.7 | 13900 | 9800 | 128 | 136 | 3.8 | 3.7 | 4.92 | 5.2 | 59 | 22 | 2.1 | 0.85 |
| 13 | 55 | M | 10.6 | 12.2 | 12000 | 9200 | 130 | 134 | 3.6 | 4.2 | 4.1 | 4.99 | 68 | 18 | 2.48 | 0.87 |
| 14 | 56 | M | 12.5 | 13.2 | 14800 | 10600 | 128 | 132 | 3.4 | 3.6 | 4.2 | 4.8 | 46 | 21 | 1.64 | 0.54 |
| 15 | 62 | M | 12.8 | 14.2 | 14500 | 11000 | 138 | 134 | 3.2 | 3.8 | 4.2 | 4.9 | 54 | 22 | 1.89 | 0.85 |
| 16 | 60 | M | 12.2 | 14.3 | 13200 | 8300 | 128 | 134 | 3.4 | 4.4 | 4.1 | 4.52 | 48 | 19 | 2.01 | 0.76 |
| 17 | 64 | M | 12.4 | 14.2 | 12700 | 9400 | 123 | 134 | 3.8 | 3.6 | 4.53 | 5.1 | 66 | 22 | 1.77 | 0.46 |
| 18 | 58 | M | 12.4 | 13.5 | 11600 | 9000 | 129 | 138 | 3.2 | 3.6 | 4.2 | 4.89 | 78 | 21 | 1.98 | 0.86 |
| 19 | 65 | M | 11.2 | 12.8 | 15900 | 8100 | 145 | 136 | 3.1 | 3.6 | 4.14 | 5.2 | 44 | 24 | 1.66 | 0.62 |
| 20 | 60 | M | 11.3 | 12.6 | 16000 | 8200 | 138 | 136 | 3.6 | 3.2 | 4.2 | 5.1 | 48 | 18 | 1.89 | 0.48 |