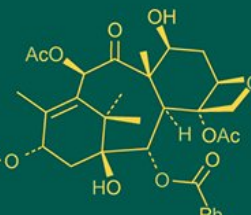
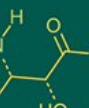
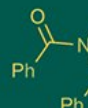


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Nutrient management on Spirulina cultivation

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Abstract

This study investigated the six-week cultivation of *Spirulina* within a laboratory setting at the Department of Food Science Technology, Ideal College of Arts and Sciences, Kakinada. This study investigates the optimization of nutrient management for *Spirulina* cultivation by evaluating the synergistic effects of Urea and Potassium. Experiments were conducted using three concentrations of Urea (80 ppm, 100 ppm, and 150 ppm) and three concentrations of Potassium (100 ppm, 150 ppm, and 200 ppm) to determine the ideal growth medium. Results indicated that the combination of 100 ppm Urea and 150 ppm Potassium found significant result and lower concentration of 80 ppm Urea with 100 ppm Potassium was found to be statistically at par. These findings suggest that moderate nutrient levels are sufficient for robust growth, preventing the toxicity associated with high nitrogen levels. By balancing nitrogen and potassium.

Keywords: Spirulina cultivation, nutrient management, urea supplementation, potassium supplementation, Microalgal growth optimization, synergistic nutrient effects

Introduction

Spirulina platensis is microalgae belongs to cyanobacteria that can carry out photosynthesis to meet its own food ^[1]. *Spirulina platensis* is distributed widely in all ecosystems, including terrestrial and aquatic ecosystems (fresh water, brackish water, and sea water). *Spirulina platensis* can grow with condition of pH 8, 5-11, temperature of 18-40 °C with low to high light intensity at range of 500350, 000 lux ^[2]. As a single cell protein with high protein and micronutrients, *Spirulina* is compatible as functional and healthy food ^[3]. *Spirulina* contains 60-71% protein, 8% fat, 16% carbohydrates, 17% carotene, 1, 6% chlorophyll-a, 18% phycocyanin, and 20-30% linoleic acid from the total fatty acids ^[4]. *Spirulina platensis* is easy to digest because of its thin membrane composed of sugar group. Furthermore, the advantage of culturing *Spirulina* is in the easiness of biomass harvesting, as the biomass can be separated from the media by filtration sized at 20-30 µm ^[5, 6]. The quality of *Spirulina platensis* depends on complex nutrients inside the culture medium. Nutrition is essential for the growth and biochemical composition of microalgae. Nutrient content necessities for *Spirulina* are macronutrients (N, P, K, S, Ca, Mg, Na), micronutrients (Cu, Zn, Bo, Co, Mo), and additional nutrients (H, C, O). Nitrogen is an element needed in the growth of *Spirulina platensis* ^[7]. In sea water, nitrogen formed as organic and inorganic nitrogen. Organic nitrogen is in the form of protein, amino acids, and urea. Inorganic nitrogen such as nitrate (NO₃), nitrite (NO₂), ammonium (NH₄), ammonia (NH₃), and molecular nitrogen (N₂) in gaseous form.

Nutrient management is the cornerstone of successful *Spirulina* cultivation. Nitrogen is the most critical element, as it is the primary building block of amino acids and chlorophyll. While nitrate-based fertilizers are traditional, Urea (CO(NH₂)₂) is an attractive, low-cost alternative. However, Urea must be managed carefully; at high concentrations, it can release ammonia, which is toxic to the culture and can inhibit growth. Simultaneously, Potassium plays a fundamental role in osmotic regulation and enzyme activation within the cell. The interaction between nitrogen and potassium determines the metabolic efficiency of the culture.

In Kakinada's tropical climate, where light intensity and temperature are often favorable for cyanobacterial growth, the optimization of these specific nutrients can significantly reduce

the "doubling time" of the biomass. Previous studies have shown that excessive nutrient loading does not always translate to higher yields and can lead to medium instability. Therefore, finding the "Goldilocks zone" the precise concentration where growth is maximized without wasting resources is essential.

This study aims to fill a gap in local knowledge by testing specific ppm (parts per million) ranges of Urea and Potassium. By focusing on 80-150 ppm for Urea and 100-200 ppm for Potassium, we seek to establish a protocol that is both scientifically sound and economically viable for the Department of Food Science. The following sections detail the experimental setup, the observations made regarding biomass density, and the nutritional implications of these varied nutrient regimes.

Materials and Methods

Materials

- Spirulina Culture: 100 mL of mother culture (starter culture)
- Nutrient Solution: Commercial or custom-prepared Spirulina nutrition (e.g., Zarrouk's medium or equivalent)
- Water: Clean, chlorine-free water (preferably filtered or distilled)
- Cultivation Tanks/Containers: Transparent or semi-transparent containers (plastic or glass)
- Aeration Setup (Optional): Air pumps or manual stirring tools
- pH Meter: For daily pH monitoring
- Thermometer: For measuring temperature
- Hygrometer: For measuring humidity
- Measuring Cylinders and Beakers: For accurate measurement of culture, water, and nutrients
- Harvesting Materials: Fine mesh cloth or filter for Spirulina collection
- Drying Setup: Clean trays or drying cloth for air-drying Spirulina biomass

Culture Source: The mother culture of *Arthrospira platensis* was obtained and acclimated to the laboratory conditions at Ideal College of Arts and Sciences, Kakinada.

Experimental Design: A factorial design was utilized with two variables

- Urea (Nitrogen Source): 80 ppm, 100 ppm, 150 ppm.
- Potassium (K): 100 ppm, 150 ppm, 200 ppm.

Cultivation Conditions

- **Vessels:** 1-liter glass flasks containing a modified Zarrouk's base (minus standard N/K sources).
- **Light:** Artificial illumination provided by cool white fluorescent lamps (12:12 light/dark cycle).
- **Agitation:** Manual stirring was performed three times daily to ensure uniform nutrient distribution and prevent clumping.
- **pH Management:** The pH was maintained between 9.0 and 10.5, which is optimal for *Spirulina*.

Data Collection: Biomass growth was measured over a 15-day period using optical density (OD) at 560 nm and dry weight analysis (g/L).

Results and Discussion

The experimental data showed a clear preference for specific nutrient ratios. The 100 ppm Urea + 150 ppm Potassium combination emerged as the superior treatment. At this level, the nitrogen was sufficient to support rapid chlorophyll synthesis without reaching the ammonia-toxicity threshold, while the 150 ppm Potassium provided the necessary ionic balance for cell expansion.

Interestingly, the 80 ppm Urea + 100 ppm Potassium treatment was found to be at par with the 100/150 combination. This is a significant finding for the "Food Science and Nutrition" perspective, as it suggests that a 20% reduction in urea and a 33% reduction in potassium does not lead to a statistically significant loss in biomass. Conversely, the 150 ppm Urea and 200 ppm Potassium treatments showed a slight decline in growth rate, likely due to increased salinity stress or localized ammonia accumulation. Spirulina contains 60-71% of protein^[4], or 55-70% based on^[11] compared to other sources such as dry soybeans (35%), grains (8-10%) or peanuts (25%) protein. These values make Spirulina essential for functional diet. Protein is needed for cell metabolism processes to support growth, which affects the synthesis process and accumulation of cell contents such as carbohydrates, amino acids, nucleic acids, and fats. Type and concentration of nitrogen source affect the variations in protein, carbohydrate and lipid contents, thus the increase in nitrogen will increase protein biosynthesis in Spirulina^[8]. Nitrogen and phosphorus are necessary to compound protein elements in cells, therefore sufficiency of these sources should be maintained^[9, 10]. The growth of Spirulina is affected by the nutrition in the medium, the higher growth rate so the higher mass density and the faster harvest time. Nitrogen content in potassium nitrate could fill in the nitrogen loss and toxic excess that resulted from urea addition. The concurrent use of urea and potassium nitrate will provide sufficient nitrogen needs for cells growth.

Conclusion

The study concludes that a nutrient regime of 100 ppm Urea and 150 ppm Potassium provides the optimal environment for *Spirulina* cultivation at the Ideal College laboratory. However, for cost-sensitive applications, the 80 ppm Urea and 100 ppm Potassium formula is highly recommended as it performs at a comparable level. These results emphasize that "more is not always better" in nutrient management. Future research should focus on the protein quality and phycocyanin content of the biomass produced under these specific optimized conditions.

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