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A Smart Bioreactor-based Production and Distribution System for Spirulina Algae in Developed Countries

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Abstract

Spirulina is a beneficial algae for delivering food security, preventing poverty, and managing malnutrition. Given the scientific data, it is possible to get all of the essential amino acids and proteins for the human diet from sources other than animal flesh, and spirulina has emerged as a plausible substitute. The coordinated, intelligent production and distribution system for spirulina algae proposed in this research may be used in developed countries. From a technological standpoint, a photobioreactor is suggested and utilized to produce algae in an appropriate environment. A dynamic mechanism for distributing spirulina is also envisaged. The last step is the offering of a management system based on transformative involvement.

Keywords*:* Smart System; Spirulina; algae; Food security, Immune System; photo bioreactor

INTRODUCTION

With increasing epidemiological and immunological disorders amongst societies, the benefit of living a healthy life has increased in modern times. Moreover, as a result of industrialization and urbanization, developing medical issues are on the rise. While health care attendance expanded in developed and developing countries, therapeutic obstacles increased.[1].

In the comprehensive administration of nations, food security is regarded as a crucial factor. [2]–[4].Up-taking more amounts of earth resources cause future side-effects for people which means food conflicts. Meanwhile, most people in the world couldn't access a valuable and sufficient diet with high level of nutrients. Based on the mentioned problems, Spirulina is an advantageous algae for providing food security, reducing poverty, and regulating malnutrition. It is feasible to obtain all of the needed amino acids and proteins for the human diet from sources other than animal flesh, and spirulina has emerged as a plausible alternative. This paper proposes a coordinated, intelligent production and distribution system for spirulina algae that can be implemented in developed nations. A photobioreactor is suggested and applied to cultivate algae in a suitable environment from a technological aspect. A dynamic distribution strategy for spirulina is also envisioned. Offering a management system based on transformative involvement is the final phase which can bring a new perspective in the near future. Because of present reasons world need novel food security supplier as an adjustment human body demand. Therefore, some nutrition with high level of protein [5], [6], carbohydrate and etc. are introduced by scientists. Main group of this nutrition contains some types of algae like Spirulina [7], [8], Nori [9], Irish Moss [10], Chlorella [11], Dunaliella [12] and etc.

Spirulina is one of the useful algae for supplying food security in poverty prevention and controlling malnutrition. The mentioned seafood can be produced in moderate weather like Portugal, Spain, and Italy. According to current researches, the whole usual protein consumption generally is 75.3 g/person/day of which 24.3 g is animal protein. People who live in developed country consume protein about 106.4 g/person/day of which animal products supply 56.1 g of total protein. The whole of necessary amino acids for the human diet could be recovered from plants by combining cereals and pulses [13], [14]. Spirulina (Arthrospira) is the most frequently utilized kind of marketable open pond cultivation. The protein value of Spirulina [8] changes between 50-70% of dry matter (DM) and the biomass yields between 30-90 tDM/ha/year. As per value of spirulina algae for supporting essential demands of body, this research intends to present a novel method in the implementation of spirulina bioreactors based on Information Technology Distribution System (ITDS) [15]. It is worth noting that the current scheme has three aspects including (i) design, invention and optimization of spirulina bioreactors, (ii) produce a new product of spirulina such as smoothie juice, different types of soap, some types of bread, some deserts, some liquors and etc., and (iii) connection of body demand (according to food pyramid) and combination of spirulina with other green foods by ITDS.

China's Yunnan Green, a high-tech foreign firm specializing in research and development, breeding, production, and sales of micro-algae health products, is an example of industrial success. Its research is in Yunnan province, which is one of the biggest three alkaline lakes naturally produce spirulina in the world. Another case is, Cyanotech which introduced a New Dietary Ingredient (NDI) [16] notice with FDA approved for algal derived natural astaxanthin [14]. They provide high-quality microalgae products for health and nutrition in a sustainable and environmentally sensitive operation. Hawaiian Spirulina is a nutrient-rich dietary supplement used for extra energy, a strengthened immune system [17], and cardiovascular [18] benefits and as a source of antioxidant carotenoids [19]. As proposed by Lafarga et [7], used Spirulina for the food and functional food industries. These days, microalgae are being used in several food industrials. The purpose of this research is to study and review uses of Spirulina in the food and functional food industries. They concluded that Spirulina has high value nutritious combinations like protein, unsaturated fatty acids and biologically active pigments such as chlorophylls, carotenoids and fibro Bili proteins [20]. One of the most important benefits of spirulina-derived pigments, compared to their counterparts, is that the ingredients have several health-boosting properties when consumed and can be used as an element in the production of new functional foods. Moons et al [21] conducted a survey on Eco-friendly Functional Food in Different Market Segments. This study investigates 1589 participants from Flanders and the factors of the adoption objective of functional food including Spirulina. The aim of usage of this new product is measured for different socio-demographic and lifestyle groups. The outcomes of this study demonstrated that women who are very much into food and often cook themselves and vegetarians and sporting people, are the bazaar parts that are most tending to approve Spirulina food. Individuals are more encouraged to utilize Spirulina in diet when they are aware with the alga and when they are ready to give up good taste for the advantages of Spirulina. Sathinathan et al [22] reviewed the design parameters of photo-bioreactor and the application growing algae. In one of the studies reviewed, the capacity of the reactor was 10 liters, the length, width and height was 320, 80, and 390 mm, respectively. Applied the reactor to culture Spirulina platensis, and utilized the reaction surface approach to improve the fermentation situations. Afterwards, investigated the optimization concentration levels and the relationships between these elements and building up a quadratic regression equation with dry weight as the dependent, light intensity, air flow, and time of cultivation and volume of medium as independent. Under the optimistically situations, the final dry weight was 1.298g/L. base on the experiment outcomes, the photo-bioreactor designed was fit to grow the algae.

IMPORTANCE OF RESEARCH AND RESEARCH ROADMAP

Some notices about present research are included in telemetry of medicine, health, food security, cosmetic and sanitary areas which are presented in the following. The advantages of the Spirulina production process in the mentioned areas are illustrated in Fig.1.

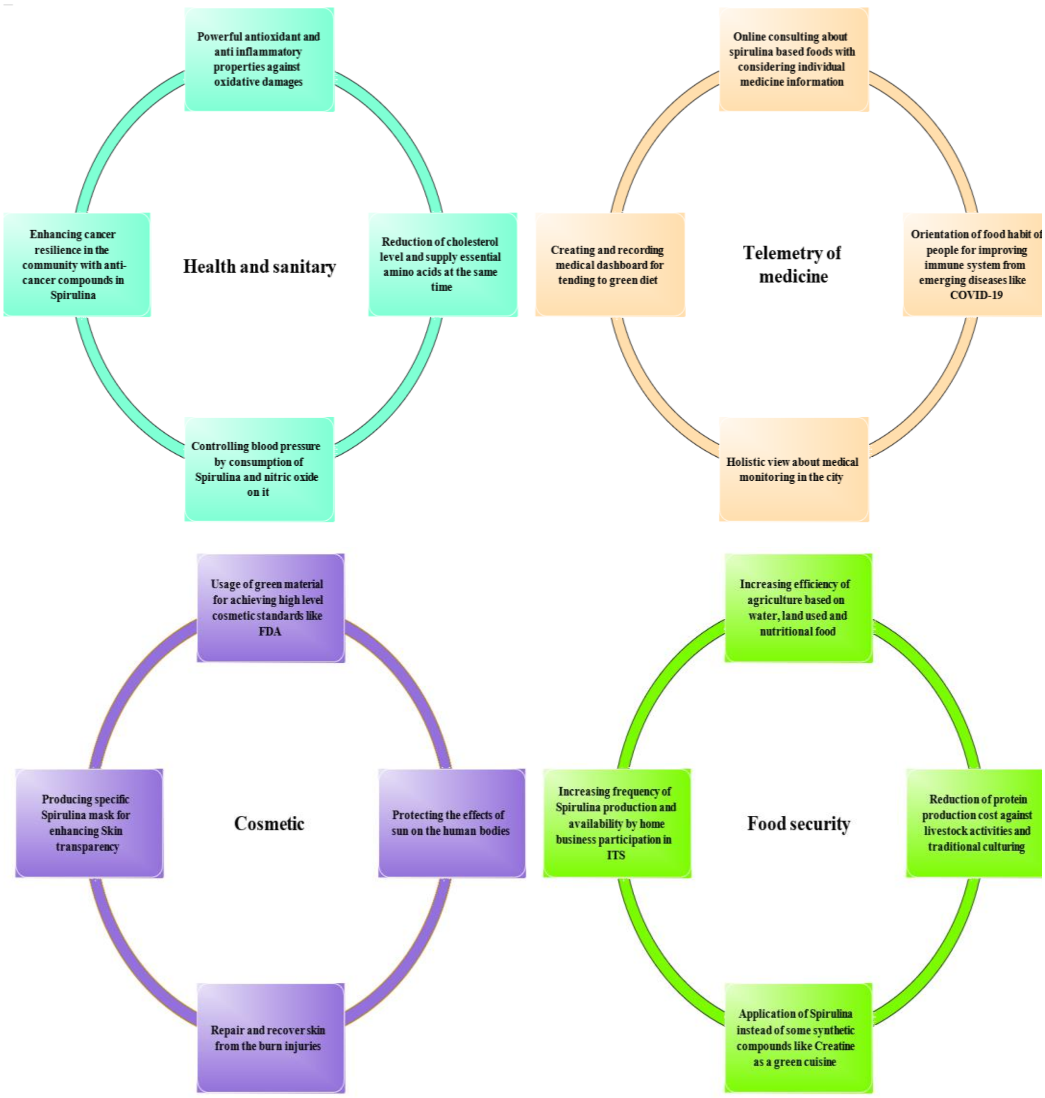

Fig. 1. The importance of present research in four areas

From the implementation aspect, the research roadmap of the present study contains development, bioreactors design, production process, ITDS invention, business administration and management system which is illustrated in Fig. 2.

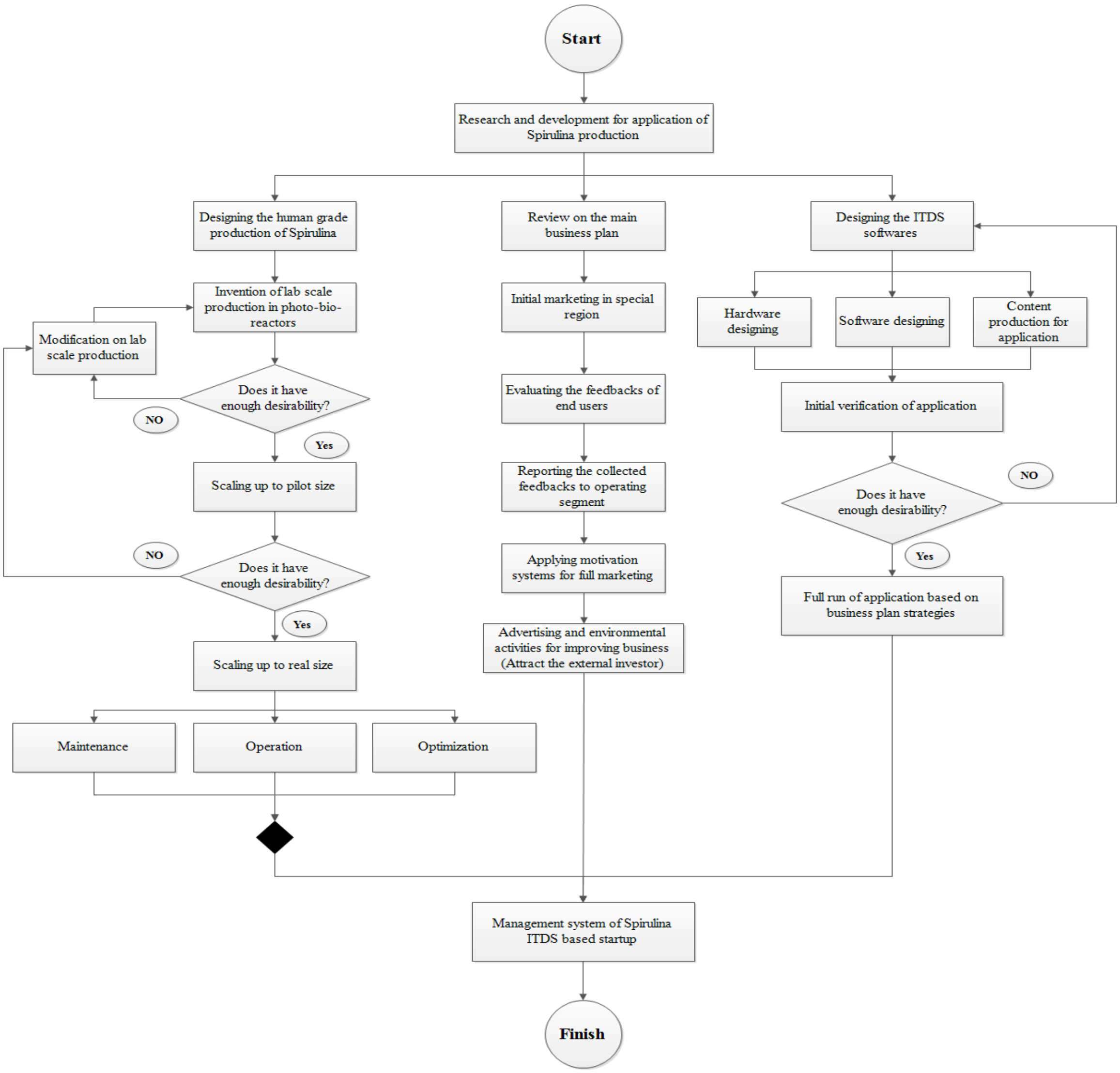

Fig. 2. The research roadmap of this study

BIOREACTOR SPECIFICATION

The produced Spirulina shape under conventional optical microscope is depicted in Fig. 3. Likewise, the image of lab scale and pilot scale of photo-bioreactors, which they are invented by present research group, are demonstrated in Fig. 4 and 5. Also, the arrange of different lights in each reactor and dried algae are shown in Fig. 6 and 7 respectively.

Fig. 3. Microscopic image of synthesis Spirulina

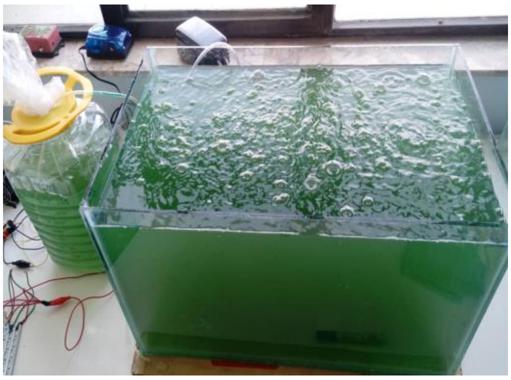

Fig. 4. Lab scale Spirulina photo-bioreactor

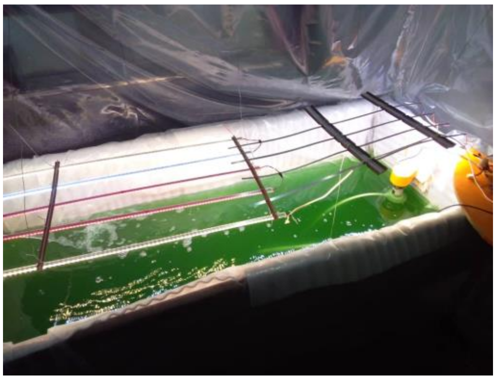

Fig. 5. Pilot scale Spirulina photobioreactor

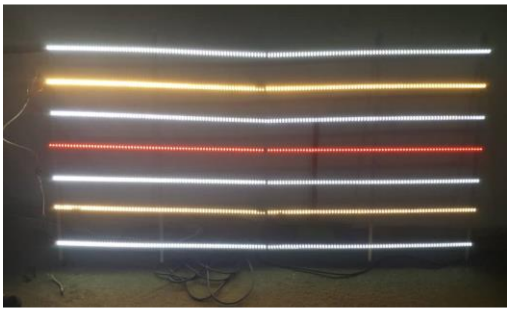

Fig. 6. Arrange of lights in photo-bioreactor

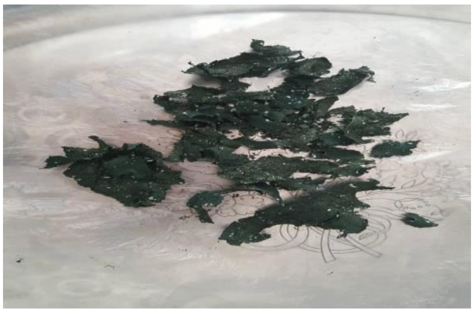

Fig. 7. Dried Spirulina in front of sunlight

All components of photo-bioreactors, which are represented in Figure 8, include the reactor glass vessel, control system, heat control, microbiological tests, pH detection, dewatering systems, drying platforms, UV disinfection system, and packaging equipment.

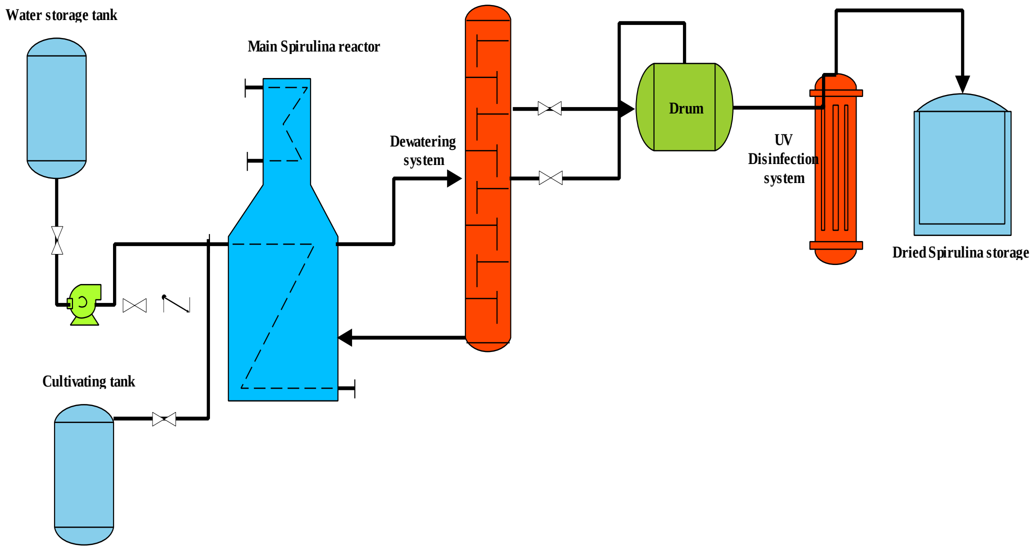

Fig. 8. Schematic plan of Spirulina production

IT SYSTEM DETAILS

The algorithm of ITDS for applying system dynamics in the distribution of Spirulina in public can be utilized. Meanwhile, the mentioned soft system suggests some food regime as per Spirulina and medical historical data from each person. Decision Making (DM) and Decision Support System (DSS) in this application are done based on individuals proposed on their diet. Therefore, this smart system is personalized for different meal goals. The algorithm of ITDS is illustrated in Fig. 9.

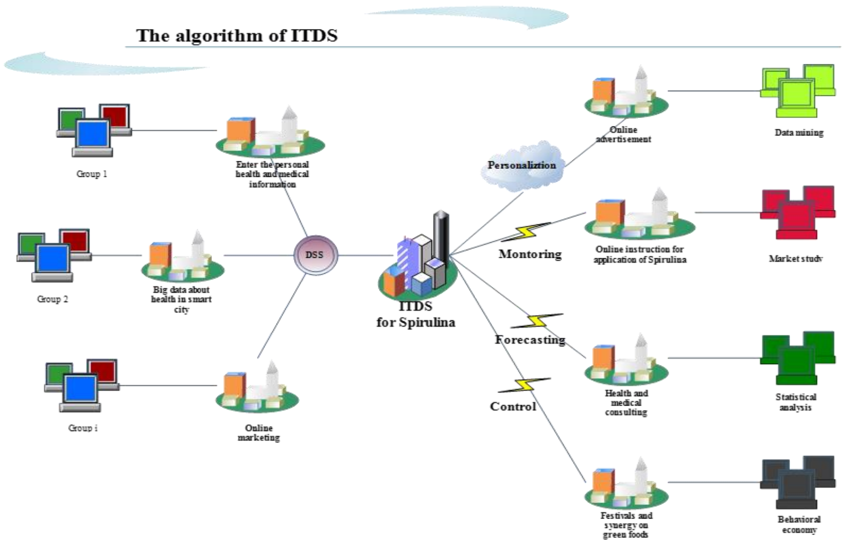

Fig. 9. Algorithm of ITDS in present research

MANAGEMENT SYSTEMS

The management system of the research can be reflected based on Transformational Participation (TP). In other words, for sequential improving this research, the goal-oriented individuals can be considered as a basis of this strategy. Therefore, the application has to change the management system according to the user's feedback. In the following, management model of the present research is depicted in Fig. 10.

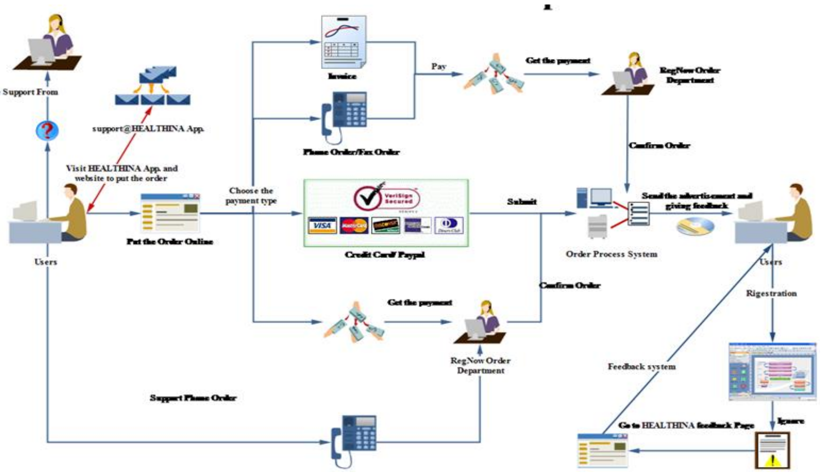

Fig. 10. The management system in this research

CONCLUSION

One of the helpful algae for ensuring food security, preventing poverty, and managing malnutrition is spirulina. According to scientific evidence, sources other than animal flesh may provide all of the essential protein and amino acids for the human diet, and spirulina has emerged as a possible substitute. In this study, a method for the structured, intelligent production and distribution of spirulina algae was presented. A photo-bioreactor was suggested from a technological standpoint and utilized for producing algae in a suitable atmosphere. A dynamic distribution mechanism for spirulina is also anticipated. Future research may be done on photo bioreactor design, nanofibers research [23]-[26], maintenance, and a well-thought-out distribution strategy.

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CONFLICT OF INTERESTS

The authors confirm that there is no conflict of interests associated with this publication.

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