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Production of value added extruded products of spirulina to outwitted the malnutrition- A comprehensive study

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Abstract
Spirulina is a unicellular, filamentous blue-green alga with spirals of varied tightness and size measuring approximately 0.1 mm in diameter. It takes less water and land to grow and may thrive in any tropical climate. Spirulina contains between 40% to 80% protein and has a rapid growth rate. Extruders are used to heat and mould products, act as reactors and alter the final product's properties. Spirulina extruded products are protein-rich, healthier, and cheaper for undernourished children. India is in the midst of an economic revolution, yet malnutrition remains a serious issue. Children and adolescents in India are more prone to suffer from protein energy deficiency, anemia, and vitamin A deficiency. Spirulina extruded foods will be high in iron, calcium and phosphorus and will thus be beneficial to malnourished children and nursing mothers and other diseases of deficiency. For several people, meat in animal flesh or seafood is the most popular type of high-protein food. However, in some parts of the world, the high cost of meat can make it unaffordable. Spirulina is currently integrated into a variety of goods, including baked desserts, beer, morning cereals, corn chips, doughnuts, food bars, frozen desserts, muffins, popcorn, salad dressing, snack foods, and soups. However, for the poor people affordability and long lasting ability will make the Spirulina extruded products popular and easily available with cheap rate to the undernourished children. Nevertheless, these extruded products are equally helpful to the any age group to fulfill the dietary deficiency.

Keywords: spirulina, extruded products, malnutrition, protein

Introduction

Spirulina is a cyanobacterium, sometimes known as blue-green algae, that grows in both fresh and saline water. It takes less water and land to grow and may thrive in any tropical climate. Spirulina is a unicellular, filamentous blue-green alga with spirals of varied tightness and size measuring approximately 0.1 mm in diameter. It, like plants, obtains energy from sunlight via the photosynthesis process. It develops and thrives in alkaline ponds and rivers with warm water. Protein is a vital element of a balanced diet. It is an excellent source of protein. Commercially, this protein in Spirulina is grown in large-scale culture systems for human and animal nutrition. Spirulina contains between 40% to 80% protein and has a rapid growth rate. Spirulina is employed as a supplemental food element in commercial aquacultures such as fish, prawn, and animal. It develops swiftly in conditions with sufficient minerals due to its high nutrient content, low nucleic acid content, and high vitamin and mineral concentrations. It is employed as a possible source of food, feed, and fuel in impoverished countries. It is farmed on a huge scale for human nourishment in clean waterways and under controlled conditions. The scientific name of Spirulina is *Arthrospira platensis* Gomont. Family-Microcoleaceae.

Spirulina has amazing properties and in many ways can be considered a Super Food. It contains the most remarkable concentration of nutrients known in any food, plant, grain, or herb. It's composed of 60% highly digestible vegetable protein, has extremely high concentrations of beta carotene, vitamin B-12, iron and trace minerals, and the rare essential fatty acid GLA – Gamma-Linolenic Acid (which people who have not been breast fed do not have). It has a balanced spectrum of amino acids, cleansing chlorophyll, and the blue pigment, phycocyanin. All the essential vitamins and minerals a body requires can be provided by Spirulina, these provide a variety of benefits for the human body like; nourishment, mental clarity, assisting in cancer recovery, depression help and many others (Piccolo, 2012). Spirulina is a nutrient-dense superfood for optimal health. Superfoods are foods that have health-promoting and disease-preventing qualities in addition to their nutritional worth. It is nature's most nutrient-dense concentrated whole food source.

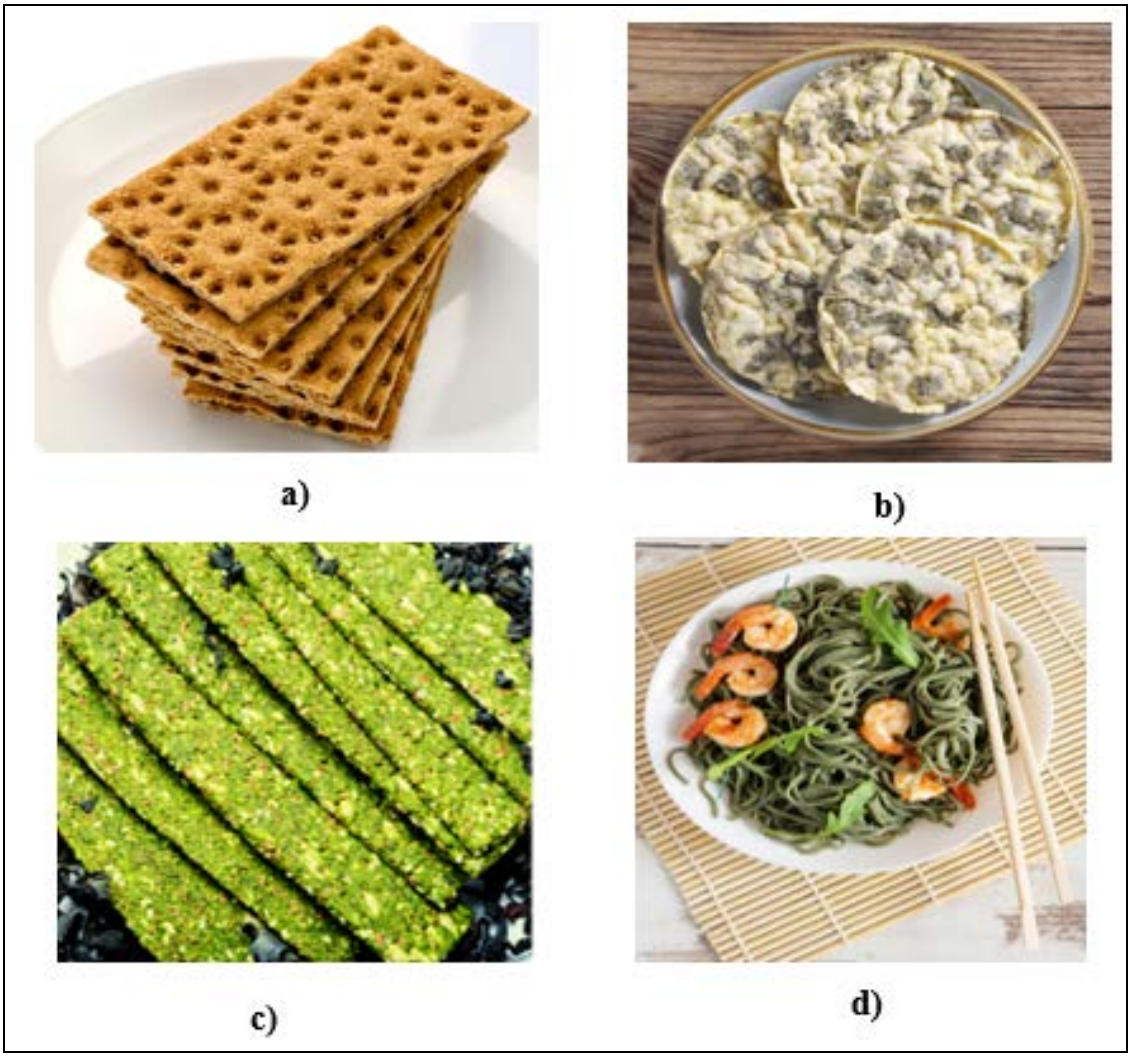

Fig 1: Spirulina Extruded Products – a) Spirulina Biscuits: b) Spirulina R**ice** Cake: c) Spirulina Energy Bars: d) Spirulina Noodles

Need of Extruded Products to Get Rid of Protein Deficiency

Extruded foods, such as chips, have become common place in the diets of a large proportion of the population. They can be made with ingredients or components that provide them with unique functional properties (Huang *et al*., 2006; Ibanoglu *et al*., 2006; Reid, 1998) [6, 8, 13]. Extrusion is the application of high heat, pressure, and moisture in an uncontrolled environment. The materials are injected under high pressure and passed through a tapering screw with water or steam used in the process. Dough pushed through a stationary barrel, or rotating shaft is processed heat happens when mechanical shearing and when the barrel is turned and the tightening the screws produce it. As a consequence, the water is rapidly evaporated.

Due to technological advancements in this field compared to conventional food processing methods, extrusion cooking technology has been commonly used in the development of snacks. Additionally, this process is used to manufacture breakfast cereals, bread, pet food, noodles, and plastic materials. Extruders are used to heat and mould products, act as reactors and alter the final product's properties (Da Costa *et al*., 2010) [2].

Proteins are a necessary component of the human diet, and sufficient amounts of high-quality protein are needed for proper growth and health. For several people, meat in animal flesh or seafood is the most popular type of high-protein food. However, in some parts of the world, the high cost of meat can make it unaffordable. Additionally, specific individuals abstain from meat for nutritional or social purposes.

Malnutrition Problem in Indian Children

Micronutrient shortages go hand in hand with undernourishment. More than half a century after independence, India is still fighting infectious diseases and related malnutrition. More than 50% of preschoolers and 30% of adults are malnourished, as well as over 70% of women and teenagers (Indian National Science Academy, 2009). As a product of bad eating habits combined with hunger, undernutrition is considered a public health issue in developed countries. It is often the result of underlying factors such as household food poverty, insufficient maternal and child care, limited access to health care, and a toxic climate. Poverty is also a significant cause of malnutrition (SWAI, 2013) [15]. Malnutrition in its more apparent types, such as stunting, wasting, and obesity, affects at least one out of every three children under the age of five across the world (UNICEF, 2019) [16]. Malnutrition in children is a significant public health concern, resulting in elevated morbidity and mortality, reduced intellectual growth and working ability, and an increased risk of adult illness. The quantity and consistency of dietary protein are critical in the care of malnourished infants. If the material,

consistency, or availability are insufficient, they can constrain development and, therefore, recovery (Michaelsen *et al*., 2009) [11].

Acute malnutrition remains a persistent problem for young children in India. Despite being leaner nutrition, a high percentage of fifth-graders have failed to achieve their fifth-grade height due to persistent under-nutrition. Stunting has decreased from 48 percent to 38.4 percent, or by one percentage point a year. Similarly, the prevalence of underweight has decreased by 0.68 percentage points from NFHS-3 to NFHS-4. Recent data, particularly for complex states, is encouraging, implying acceleration (Aayog, n.d.). In India, undernutrition rates have remained persistently high – especially among infants, young children, teenage girls, and women throughout their lives – particularly among disadvantaged/excluded population groups and those living in areas or circumstances of high nutritional vulnerability and multiple deprivation. The NFHS-3 (2015-16) and NFHS-4 (2016-17) national estimates are used to make comparisons (2019-20). For body build-up, Spirulina extruded products are protein-rich, healthier, and cheaper for undernourished children. Hence this study aims to carry out characterization, development, and storage behavior of Spirulina extruded foods to curb childhood malnutrition in India.

Iron is essential for a child's physical and mental growth. Anemia is the world's most frequent dietary deficit. Over 2 billion people worldwide are anaemic. Anemia is more common in Indians of all ages than in other developing countries. Iron supplementation has been shown to improve haemoglobin and growth. Since iron supplementation has had limited success in treating anaemia, attention is turning to food-based treatments that may have more far-reaching and long-lasting advantages. Food-based initiatives aim to improve nutrition by expanding access to a diverse diet rich in micronutrients. An urgently needed more comprehensive strategy to combat iron and other micronutrient deficiencies must include food-based treatments. Spirulina has a protein that may aid anaemia and other deficient illnesses.

Spirulina Extruded Products

Hippocrates stated 2500 years ago, "Let food be your medicine, and medicine be your nourishment." Food as medicine idea is more relevant today than ever before. In any country, health and nutrition are the most significant contributory elements to the human index assessment. India is in the midst of an economic revolution, yet malnutrition remains a serious issue. “Youth are a nation's future holders.” As a result, healthier growth means greater national development (Fatima & Srivastava, 2017) [3]. (Hussein *et al*., 2021) [7] concluded in their research that, Spirulina is entirely safe to consume and has the potential to be utilized in the production of functional meals. Spirulina-enriched pasta is a high-protein, high-antioxidant source of carbohydrate and protein. Sensory ratings decreased as the degree of enrichment was raised, indicating a decrease in the quality of the product. It is possible that the low concentration of 2-pentylfuran and hexanal taste chemicals is responsible for this decrease. Due to the concentrated nutrients included in spirulina, it is an excellent dietary supplement for people of all ages and lifestyles. Spirulina contains about 60% full, readily digested protein. Spirulina is a complete protein, including all necessary amino acids. It has the highest amount of beta-carotene of any whole food; it is the finest whole food source of beta-carotene (Sharoba, 2014) [14].

Value Added Products of Spirulina

Spirulina is currently integrated into a variety of goods, including baked desserts, beer, morning cereals, confectionery, corn chips, crackers, doughnuts, food bars, frozen desserts, juice smoothies, muffins, pasta, popcorn, salad dressing, snack foods, and soups. Numerous cook books on Spirulina have been released (Radha & Veluchamy, 2017) [12]. (Gautam *et al*., 2015) [4] stated in their research, the nutritional profile of handmade extruded goods manufactured from a composite flour of (foxtail millet, wheat, and chickpea) has a great deal of potential for meeting the nutritional needs of vegetarians and the impoverished in our nation. The fortified food products have a higher nutritional value compared to control samples. Spirulina extruded foods will be high in iron, calcium and phosphorus and will thus be beneficial to malnourished children and nursing mothers and other diseases of deficiency. (Fatima & Srivastava, 2017) [3] have studied the nutritional analysis of all nutrients present in the biscuits, pasta and noodles and have been done comparison of the controlled sample with the Spirulina extruded products.

Discussion on the Value Added Extruded Products of Spirulina

(Fatima & Srivastava, 2017) [3] Investigated that, food items fortified with Spirulina at 10% and 5% concentrations were approved on organoleptic measures, with the most acceptable goods remaining within a satisfactory range throughout storage. The results indicate that produced food products are healthy and have a considerably higher nutritional value than control samples. Thus, this useful product has a high extrusion potential and a greater acceptance on organoleptic criteria, implying that the improved quality of Spirulina enriched food items benefits the customer significantly. A value-added extruded product containing 5% Spirulina, 95% Wheat flour, and 5% Corn flour was produced, and sensory criteria such as taste, odour, texture, colour, and appearance were determined to be acceptable (Lakshmi *et al*., 2017) [10].

When compared to the control, extruded goods containing spirulina and whey water had a significantly different nutritional content. For one month, the produced extruded goods were microbially analysed for fungus and bacteria and confirmed to be safe.

Consumers want low-fat, sugar-free, and salt-free foods that are vitamin and mineral fortified and free of synthetic chemicals. Rapid industrialization, urbanization, the increasing participation of women in the labour force, and consumer interest in health foods have all led to a rise in demand for quick or convenience meals. Over the last several decades, there has been an explosion of quick and ready-to-cook convenience foods that need minimal preparation on the side of consumers. The challenges facing the food sector will be meeting the needs of a competitive global market while also developing new consumer items. Consumers today anticipate an ever-expanding selection of snack items. There are already available low-nutrient snack foods. Extrusion has evolved into a crucial technique in the food processing industry. Today, the food extruder is used to make pasta, ready-to-eat cereals, snacks, and confectionery, as well as modified starches for soups, infant

food, and fast meals, beverage bases, and texturized vegetable proteins. Extrusion cooking is a high-temperature, rapid processing method for developing new innovative items. It is economical in terms of energy, time, and money. Protein Energy Malnutrition is a phrase that refers to a collection of clinical diseases that are caused by a concurrent protein and caloric deficiency in varying amounts. It is particularly prevalent in infants and young children and is frequently associated with infections and malnutrition. Children and adolescents in India are more prone to suffer from protein energy deficiency, anaemia, and vitamin-A deficiency.

(Vijayarani *et al*., 2012) [17] a value-added extruded product may be created by adding up to 5% spirulina powder. By incorporating spirulina powder into the extruded product, the macro and micronutrient content will be increased. The product is confirmed to be microbially safe for the month studied. This created extruded product will not only improve the population's nutritional status, but will also address a variety of nutritional issues prevalent in the community. Material generated from HMEC (High Moisture Extrusion Cooking) is adaptable and may be used in place of meat components in the majority of recipes. HMEC technology permits the creation of a variety of forms, sizes, and textures of protein material, which may then be processed further into burgers, sausages, schnitzels, meatballs, nuggets, or toppings and fillings (Grahl, 2019) [5].

Conclusion

Spirulina is a complete protein, including all necessary amino acids and has the highest amount of beta-carotene of any whole food. Spirulina-enriched pasta is a high-protein, high-antioxidant source of carbohydrate and protein. The nutritional profile of handmade extruded goods has a great deal of potential for meeting the nutritional needs of vegetarians and the impoverished in our nation. Spirulina-fortified food products are healthy and have a considerably higher nutritional value than control samples. When compared to the control, extruded goods containing Spirulina and whey water had a significantly different nutritional content. Consumers want low-fat, sugar-free, and salt-free foods that are vitamin and mineral fortified and free of synthetic chemicals. The challenges facing the food sector will be meeting the needs of a competitive global market while also developing new consumer items. Food extruder is used to make pasta, ready-to-eat cereals, snacks, and confectionery. Extrusion cooking is a high-temperature, rapid processing method for developing new innovative items. Children and adolescents in India are more prone to suffer from protein energy deficiency, anemia, and vitamin A deficiency. A value-added extruded product may be created by adding up to 5% spirulina powder. Extruders are used to heat and mould products, act as reactors and alter the final product's properties. Dough pushed through a stationary barrel, or rotating shaft is processed heat happens when mechanical shearing and when the barrel is turned. More than 50% of preschoolers and 30% of adults are malnourished, as well as 70% of women and teenagers (Indian National Science Academy, 2009). Malnutrition in children is a significant public health concern resulting in elevated morbidity and mortality, reduced intellectual growth and working ability, and an increased risk of adult illness. Acute malnutrition remains a persistent problem for young children in India. Spirulina extruded products are protein-rich, healthier, and cheaper for undernourished children. The production of value added extruded products of Spirulina to out witted the malnutrition problem of children and women in India. For that it is essential to take step forward regarding the making of Spirulina extruded products which can be made easily in low cost and readily available to the villages, tribal areas where there is more in need of such extruded products which will be available in low cost and durable also. The cooking method of such extruded products are also easy such as pasta, noodles, soups which needs only water and fuel to cook. In this way inclusion of Spirulina in malnourished people will be very easy in their diet like biscuits, rice cakes, energy drinks, *Chikki*, energy bars and many more.

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