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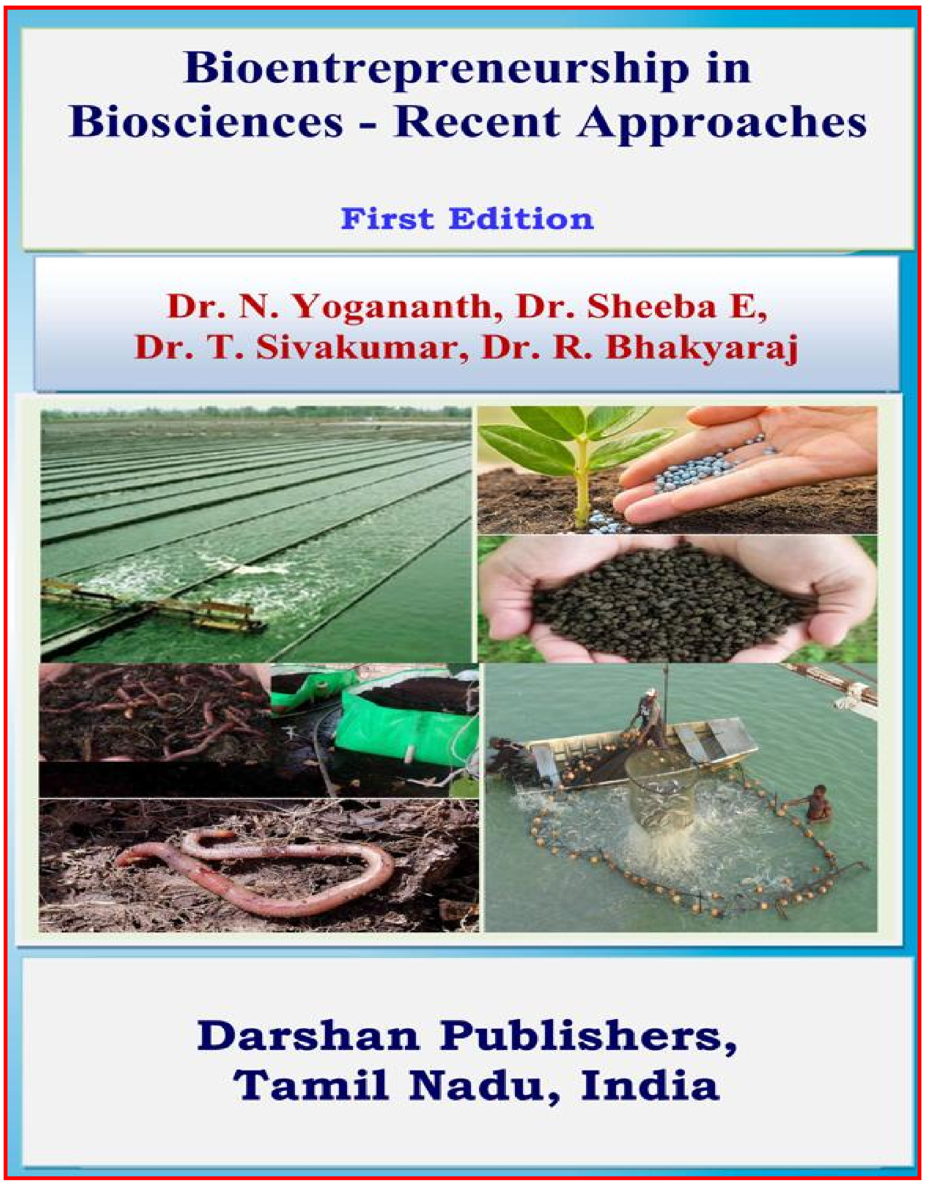

Single Cell Protein – A Potential reserve product and propitious field for Budding Entrepreneurs

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Introduction

An upsurge in advancements has taken the mankind to a new level of progress in all the field may it be economically or commercially. At the same time the needs and wants have also been increasing, through these drastic developments, rise in populations is stimulating a major problem in meeting food requirements across the globe. And simultaneously climate change is also impacting on the Agriculture, variations in seasons, inadequate rainfall, higher temperatures is eventually tapering the growth and yield of the crops. The precipitation patterns are changing radically leading to short-run crop failures. And following the conventional methods will nowhere meet the needful food requirements, especially proteins.

The growing Agricultural practices and modern methods have been developed so as to increase the yield and expanding the growth and production, utilizing the various different kinds of beneficial microbes, with less cost, ecofriendly way and easy protein productions and purification. And also utilizing the waste generated more economically has gained wide recognition, providing job opportunities and help meeting the requirements.

It is estimated that by 2050, the world should produce more than 1,250 million tonnes of dairy products per year so as to meet the global requirements. On the other hand the plant protein can also be derived but the production rate is low and conversion of this plant protein to meat protein is inefficient (~6 kg of plant protein is needed to produce 1 kg of meat protein).The necessity of conversion of plant protein to animal is because of the percentage of protein that is meat generally having about 45%, milk about 25% and of soybean about 35%. Plant-based proteins from millets, chickpeas,lentils are nutritionally valuable sources of protein, but cultivating them requires good fertile land and good amount of water. Protein can also be provided through the cultivation of various microbes and algae, which contain more than 30% protein in their biomass and which can provide a healthy balance of essential amino acids. Microbial proteins in general are referred to as Single Cell Protein. And the idea of production of such potential food reserve like Single Cell Protein, yearning for an independent and successful business can go hand in hand , if planned systematically and projected. It can be one of the propitious field for all the growing entrepreneurs. There are many scientists cum entrepreneurs who have made gold out of their ideas and hard sciences as entrepreneurs work and also have created a bench mark in the various fields of life**.**

Scope

SCP has created a new pathway in producing the protein supplements particularly for human consumption. Especially yeast based SCP has created a great demand of protein supplements in the market. The left over yeast cells after the production of SCP can be converted into byproducts that can be used as animal feed. As SCPs are widely used as supplements rather than direct food as it provides omega-3 fatty acids, carotenoids and vitamins, with protein as a corollary benefit which is of prime importance. Algae also have well-established markets for both food and feed applications.Bacterial SCP is primarily restricted to the feed industry. There are many biotech companies have got started in the production of SCP. Thus, greater expansion in available SCPs for animal feed than for human food can be expected. It is a huge field where in various substrates can be experimented and the microorganisms of different species can also be expanded for more efficient quality and quantity of SCP.

Single Cell Protein

Single cell Proteins(SCP) are protein extractions that are extracted from different microorganisms and different organic substrates , which constitutes the high protein content utilized for human consumption as well as animal feeds. It was in 1781 , different processes were proposed so as to get maximum yield of yeast for the production of various food substances. It Single cell protein consists of proteins, fats carbohydrates, ash ingredients, water and other elements such as phosphorus and potassium. And consumption of microorganisms is no strange as we know they are involved directly in fermenting foods, widely known probiotics having enormous amount of health benefits and as well as consumption of mushrooms for its protein source. It was at the same period when Max Delbruck and his colleagues discovered the high value of brewer's yeast as feeding supplement for animals and simultaneously researches were carried out for the production of SCP. During the world war I and world war II, SCP obtained from yeast was employed on a large scale production in German to compensate the food shortage during the war period.

It was a great breakthrough in the field of Biotechnology. As and when there was an improvement in the field of fermentation and introduction of various fermentors, it created a great platform and backbone for all the mass cultivation of different types of fermented foods and other products such as enzymes, organic acids, antibiotics in an industrial level. And thus creating a path in overcoming the scarcity of food. These techniques were also implied for the large scale production of various proteins.

The new agricultural practices have been widespread, where high protein cereals such as soybeans and other millets but now utilizing microbes for the production of proteins has gained huge success. The microorganisms such as bacteria, algae, yeast and filamentous fungi can be used for the production of single cell protein.

Microbial source of Single Cell Protein

As mentioned previously SCP can be produced by different microorganisms such as Bacteria, Fungi, Algae where in the percentage of protein produced may differ from organism to organism and also within the species.

Fungal SCP

Fungi grown as SCP will generally contain 30–50% protein. In addition to protein, SCP derived from fungi is expected to provide vitamins primarily from the B-complex group (thiamine, riboflavin, biotin, niacin, pantothenic acid, pyridoxine, choline, streptogenin, glutathione, folic acid, and p-amino benzoic acid).

Aspergillus fumigatus,*Aspergillus niger*. *Rhizopus cyclopean*, *Candida tropicalis*, *Cladosporium cladosporoides*, *Pencilliumcitrinum* , *Trichoderma harzianum*, *Fusarium venenatum* etc

Yeast SCP

It was Professor Carol Winston in 1966 used the word microbial protein. Single cell protein was produced by yeast *Sacharomycescerevisiae* in Germany during World War I. Yeasts are the best organisms in the production of single cell protein and also superior when compared to other microorganisms such as bacteria and algae. It is easy to culture them which can

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yield more protein content with less nucleic acids. The yield of protein is 50% of the entire dry weight. It can grow readily in different acidic levels. And the content of aminoacidsare also more in contrast to other traditional protein sources.

Saccharomyces cerevisiae, Candida utilis, Rhodosporidium, Cryptococcus spp, Pitchia spp

Algae SCP

Microalgae which are produced for human or animal consumption typically have high protein content (e.g., 60–70%). They also provide fats (with ω-3 fatty acids and carotenoids being of particular interest), vitamins A, B, C, and E, mineral salts, and chlorophyll. They have relatively low nucleic acid content

Chlorella pyrenoidosa, *Chondruscrispus*, *Chlorella sorokiana*, *Euglena gracilis*, *Arthospira platensis* (*Spirulina platensis*), *Chlorella vulgaris*etc

Bacterial SCP

They are generally high in protein and possess faster growth rate. The smaller size of bacteria and the yield of biomass is also less. The nucleic acid content is quite high in bacteria which have the tendency to increase uric acid level in human blood upon consumption.

Pseudomonas fluorescens, Lactobacillus, Bacillus megaterium, Bacillus subtilis, Bacillus cereus, Rhodopseudomonas palustris

Composition	Fungi	Algae	Yeast	Bacteria
Protein	30 - 45 %	40 – 60 %	45 – 55 %	50 – 60 %
Nucleic Acid	7 – 10 %	3 – 8 %	6 – 12%	8 – 12 %

Average Percentage of Protein Content and Nucleic Acid

Production of SCP

Single cell protein (SCP) refers to dead and dry cells of microorganisms like yeast, bacteria, fungi, and algae. SCP contains a high amount of protein with all essential amino acids. Microorganisms serves as good source of SCP as it can multiply and grow rapidly utilizing the minimum amount of nutrition. In this scenario the bioconversion of fruit wastes into SCP presents an upcoming technology to solve the worldwide protein scarcity. The utilization of waste materials facilitates the economic production ofhigh-concentration protein sources and the and the alleviation of pollution burdens by using bioreactors utilizing hardly any land space.

Substrates utilized for the production of SCP

The substrates which have been used for SCP production by yeasts include sorghum hydrolysate, sulfate waste liquor, pawn-shell wastes, dairy wastes, methanol, molasses, starch and plant origin liquid waste. The worldwide, large-scale development of SCP processes has contributed greatly to the advancement of present day biotechnology. In developing SCP processes new technical solutions for other related technologies in waste water treatment, production of alcohol, enzyme technology and nutritional science also improves. The future of SCP will be heavily dependent on reducing production costs and improving quality by fermentation, downstream processing and improvement in the producer organisms as a result of conventional applied genetics together with recombinant DNA technologies. The most common key ingredient for the production of SCP is Carbon source that includes both monosaccharides and disaccharides that can be easily utilized by the microorgansims. The choice of substrate mainly depends on the process that is involved, suitable substrate and type of microorganism that is involved. Most commonly used substrates include potential substrates for SCP include bagasse, citrus wastes, sulphite waste liquor, molasses, animal manure, whey, starch, sewage, etc.

1. There are some high commercially valued substrates such as gas oil, derivatives of alkanes, methane etc. Bacteria and yeasts these high commercial energy sources. British Petroleum used two yeasts, Candida lipolytica and C. tropicalis and C12-C20 alkanes as substrate which is of the wax fraction of gas oils for treating. Some crude oils contain up to 15% in wax. And the protein was named as TOPRINA, which was marketed. Due to hike in the oil prices, utilization of oil fraction got reduced. Methanol was used by methanol -utilizing bacterium *Methylophilusmethtlotrophus* was constructed by ICI (Imperial Chemical Industries Company), UK. This ICI SCP was extensively used for animal feeding.
2. The other form of substrate is from wastes in particularly from agriculture and industry. Utilization of wastes on the other side reduce environmental pollution. Cellulose, lignin, hemicellulose, starch will undergo acid hydrolysis and enzyme digestion to remove other undesirable produts.Wood can be also cooked in a medium containing calcium sulfite with excess free sulfur dioxide. Lignin can be converted to lignosulfonates and

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hemicellulose is hydrolysed to monosaccharides and may be further broken down to furfurols. The amount of free sugars in the spent liquor is variable with the type of procedure chosen, as various cellulose fibers may be obtained with different degrees of degradation. Spent sulfite liquor has been used as a substrate for fermentations since 1909 in Sweden and later in many other parts of the world.

3. The fermentation process requires pure culture wherein the organism is isolated from a source, poured onto the suitable media and sub cultured to get a pure form of the desirable organism. For large scale production, the amount of inoculum(the population of microorganisms or cells that is introduced in the sterilized fermentation medium or any other suitable medium)used will be in liters together based on the fermentor's size, the production medium is formulated with right proportion of Carbon, nitrogen sources, if required trace amounts of salts, metals etc, the production media can vary from organism to organism. And optimum temperature, optimum ph, should be maintained. The preparation of inoculum and maintaining all the physical and chemical parameters can be referred to as Upstream processing. Once the production is formed it undergoes various cell separation, filtration so as to eliminate the undesired product. The process carried out for product recovery is referred as Down stream processing.

Types of Fermentation

The microbial cells produced for the production of proteins or used for the inoculum production in food industry or production of antibiotics , enzymes or for the treatment of waste large scale of fermentation process is very much required. Fermentation is a process where organic molecules such as sugars are broken down anaerobically to give alcohol, CO_2 and desirable product.

There are two types of fermentation process,

a. Submerged fermentation
b. Semisolid state fermentation

a. Submerged fermentation : it is a method of fermentation where the contents(substrates,enzyme) are submerged in liquid medium such as oil, alcohol and nutrient medium.Submerged Fermentation (SmF) can also be called as Liquid Fermentation (LF) SmF utilizes free-flowing liquid substrates, such as molasses and broths.The liquid media contains all the required nutrients such as industrial enzymes, antibiotics etc.,.The process of SCP production involves some engineering operations likely stirring, mixing of multiphase system, heat transfer from liquid phase to surroundings and

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transport of oxygen. The most important step in this type of fermentation is to provide right amount of aeration. Because during the fermentation process there is lot of heat that is released to remove the heat cool air is passed into the fermentors.Single cell organisms are usually recovered by the process of centrifugation and followed by filtration method using appropriate type of membrane, when the biomass contains mostly filamentous fungi. The moisture should be completely removed and finally the product is dried and packed.

b. Semisolid state fermentation : SSF is defined as any fermentation process in which microorganisms grow on solid support materials in the absence of free-flowing water. Two types of solid supports can be used in SSF: natural supports (e.g. lignocellulosic wastes) and inert supports (e.g. plastic foams).

SCP – Food Processing

The effective use of microbial protein for human food requires:

- Cell wall is broken down to give out the cell protein
- Reduction of nucleic acid content

For the cell wall of an organism to be broken there are many ways like physical, chemical and enzymatic methods. Mechanical integration of cell wall can be carried out either by crushing, crumbling, grinding, pressure homogenization or ultra sonification .Various enzymes or combination of enzymes can be used to digest and disrupt cell wall, either partially or completely. Enzymatic hydrolysis of cell wall is attractive in terms of its delicacy and specificity for only the cell wall structure. It may be used as an alternative to the mechanical disruption, especially for materials that can be inactivated during the mechanical process and it can be performed by endogenous or exogenous enzyme from other microorganisms.

Non-mechanical methods

Chemical treatment: acid, base, solvent, detergent

Enzyme analysis: lytic enzymes, phage infection, autolysis

Physical treatment: freeze-thaw, osmotic shock, heating and drying

Mechanical methods

High pressure homogenization

Wet milling

Sonification

Several methods have been proposed to reduce nucleic acid levels in SCP. These methods involve chemical and enzymatic treatments. Each has disadvantages both in terms of cost and potential nutritional concern. In 1977, the extraction of nucleic acid by acidified alcohol, salt, acid and alkalis has been proposed. Alkaline extraction of **microbial biomass** at elevated temperature was also used in 1970. The process resulted in high protein yield with low nucleic acid.

Economic aspects of Production of SCP

Fermentation is a long process wherein large fermentors are used and also the biomass is production is also high. The more the biomass production, heat generated will also be high which in turn requires more cooling air of aeration, the production economics should be given more prominence. The Economics factors that should be taken into account during this fermentation period are: Investment, Energy, Operating costs, Waste, Safety and the Global market.

A. Substrate Cost : The most important requirement for the production of SCP is the suitable substrate, the organic waste products that are given out from the food and beverage industry, paper industry, agriculture, and households can be utilized to cutoff the cost.

B. Utility services : the energy that is utilized for sterilization, steaming, cooling requires high amount of energy as the process itself is huge and the biomass produced is also in higher quantities hence it is better to choose renewable sources such as solar, wind power, hydro or geothermal energy.

C. Product cost : Considering the downstream processes the cost of a product can be defined, production can be done controlling all the necessary physical and chemical factors but recovering the desirable product is a tedious and expensive which comprises different separation, filtration and purification techniques.

D. Safety hazard and Toxicology : It is a significant step that had to be too care from the starting stage of production that is from the selection of the strain, substrate, media, fermentation till recovery and also keeping the nutrition in mind, any of these steps should not alter the nutrient quality of that particular protein, toxicology tests should be done before and after packaging and marketing.

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Significance of SCP

Single cell proteins have application in animal nutrition as: fattening calves, poultry, pigs and fish breading in the foodstuffs area as: aroma carriers, vitamin carrier, emulsifying aids and to improve the nutritive value of baked products, in soups, in ready-to-serve meals, in diet recipes and in the technical field as: paper processing, leather processing and as foam stabilizers. The production of single cell protein takes place in a fermentation process. This is done by selected strains of microorganisms which are multiplied on suitable raw materials in technical cultivation process directed to the growth of the culture and the cell mass followed by separation processes. Process development begins with microbial screening, in which suitable production strains are obtained from samples of soil, water, air or from swabs of inorganic or biological materials and are subsequently optimized by selection, mutation, or other genetic methods. Then the technical conditions of cultivation for the optimized strains are done and all metabolic pathways and cell structures will be determined.

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