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Single Cell Protein - An Alternative Microbial Protein Source

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Abstract

The term single-cell protein (SCP) is used to describe protein derived from cells of microorganisms such as yeast, fungi, algae and bacteria which are grown on various carbon sources for synthesis. The dried cells of microorganisms or the whole organism is harvested and consumed. This is a protein source for human food supplements and animal feeds. SCP production may have potential for feeding the ever-increasing world population. Massive quantities of SCP can be produced in a single day. As a source of protein, it is very promising with potential to satisfy the world shortage of food while population increases.

Introduction

SCP is considered a major source of feed for animals. Bacteria, yeast and algae are produced in massive quantities of protein sources as food for animals and humans. The production of valuable biological products from industrial and agricultural wastes is considered through the bioconversion of solid wastes to added-value fermented product, which is easily marketable as animal feedstock. The waste streams that otherwise would cause pollution and threaten the environment can be considered raw material for CSP production using suitable strains of microorganisms.

The Process of SCP Production from any Microorganism or Substrate would have the Following Basic Steps:

- Provision of a carbon source; it may need physical and/or chemical pretreatments.
- Addition, to the carbon source, of sources of nitrogen, phosphorus and other nutrients needed to support optimal growth of the selected microorganism.
- Prevention of contamination by maintaining sterile or hygienic conditions. The medium components may be heated or sterilized by filtration and fermentation equipments may be sterilized.
- The selected microorganism is inoculated in a pure state.
- SCP processes are highly aerobic (except those using algae). Therefore, adequate aeration must be provided. In addition, cooling is necessary as considerable heat is generated.
- The microbial biomass is recovered from the medium.
- Processing of the biomass for enhancing its usefulness and/or storability.

Nutritional Value of SCP

A long-term use of SCP is required to consider and remove any toxicological effects and carcinogenesis. The positive point of view for SCP is the high content of protein with sufficient enzymes, minerals and vitamins. The protein content of SCP is very high. Dried cells of

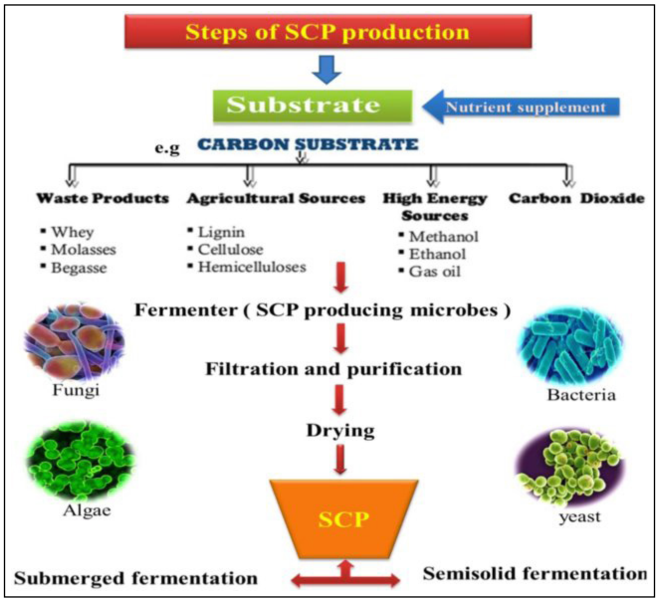

Figure 1: Steps in the production of Single Cell Protein (Source: Sharif *et al*., 2021)

Pseudomonas sp. grown on normal petroleum-based liquid paraffin contain 69% protein. Algae normally possess about 40% protein (Venkataraman *et al*., 1977). The protein content of SCP is absolutely dependent on the raw material used as a carbon source and the microorganisms grown on the media. The proteins of the microorganisms contain all the essential amino acids. The following table presents the average protein contents of bacteria, yeast, fungi and algae.

Table 1: Cellular composition of SCP from various microorganisms (dry weight percent)

Composition	Yeast	Bacteria	Fungi	Algae
Protein	45-55	50-65	30-45	40-60
Nuclei acid	6-12	8-12	7-10	3-8
Fat	2-6	1.5-3	2-8	7-20
Ash	5-9.5	3-7	9-14	8-10

Genetically Modified Organisms in SCP Production - Future Possibilities

Use of genetically modified organisms (GMO) in food and feed has not yet found public acceptance in Europe, although there is more acceptance elsewhere in the world. GMO consumption accumulates, they may gain further acceptance as protein sources become scarcer, particularly if a market develops for healthy or personalized nutrition (Nasseri *et al*., 2011).

GMO yeast from bioethanol factories can already be used as cattle feed in some countries. Use of genetic elements from the host itself (self-cloning) often means that no foreign DNA is introduced. Although, Goldberg (1988) discussed the prospect of using genetically engineered microbes as SCP in the 1980's as a means of improving process economics by producing co-products (*e.g*., an enzyme, organic acid, or antibiotic), the concept was not pursued and has only gained more interest and acceptance in recent years.

A wide range of advantages in SCP products from genetic modification has been considered. For example, DuPont has genetically engineered a yeast to produce long-chain omega-3 fatty acids, which are essential to human health (Xie *et al*., 2015). Genome sequencing and genetic engineering also allow disruption of genes involved in toxin production and thus improved safety of some SCP products. Disruption of genes can be achieved by traditional mutagenesis and screening, but the process may introduce undesired mutations into the product, whereas genetic modification is quicker and more specific. This will be aided by new technologies, such as Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) that allows specific editing of the genome without introduction of new DNA. Strains which have been modified using CRISPR are not necessarily considered GMOs.

Advantages of Production of SCP from Microorganism

• Microorganisms have a high rate of multiplication and, hence, rapid succession of generations (algae: 2-6 hours, yeast: 1-3 hours, bacteria: 0.5-2 hours). They can be easily genetically modified for varying the amino acid composition.

• A very high protein content 43-85% in the dry mass.

• They can utilize a broad spectrum of raw materials as carbon sources, which include even waste products. Thus, they help in the removal of pollutants also. Strains with high yield and good composition can be selected or produce relatively easily.

• Microbial biomass production occurs in continuous cultures and the quality is consistent, since the growth is independent of seasonal and climatic variations.

• Land requirement is low and is ecologically beneficial. Algal culture can be done in space that is normally unused and so there is no need to compete for land.

• A high solar-energy-conversion efficiency per unit area. Solar energy conversion efficiency can be maximized and yield can be enhanced by easy regulation of physical and nutritional factors.

Conclusion

The protein content of SCP is absolutely dependent on the raw material used as a carbon source and the microorganisms grown on the media. The proteins of the microorganisms contain all the essential amino acids. The parameters used by them to evaluate the ranking of SCP showing that nucleic acid from algae is safer than fungi and bacteria. Nucleic acid from fungi is much better than bacteria due to their low nucleic acid contents. Therefore the ranking will be **algae > fungi > bacteria**. The positive point of view for SCP is the high content of protein with sufficient enzymes, minerals and vitamins.

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