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Microorganisms as an alternative source of protein: Mushrooms as single cell proteins (SCP)

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Abstract
The Single cell protein is a protein extracted from single celled microorganism, algae, yeasts, or bacteria. It is used as a substitute for protein rich foods, especially in animal feeds or as dietary supplements. As the population increases there is scarcity of protein for world so to fulfill these needs and saving of protein from plant and animal origin the SCP is third option. The term SCP was firstly coined in1968. Single cell protein (SCP) has many applications in food and feed industries. The microorganisms which can be used as SCP include a variety of bacteria, marine microalgae, yeasts and molds. Production of SCP using raw materials as substrate provides an economical source of protein for use in animal feed or human food. SCP always found to meets dietary requirements for protein. Various types of microorganisms have been used to convert raw substrates into biomass. It has been found that SCP production would arise as a promising way to meet the problem of worldwide protein shortage.

Keywords: animal feed, applications, biomass, single cell protein, uses

Introduction
Rapid developments in microbial protein production occurred during the 1960s and 1970s. Extensive research was conducted on a wide range of microorganisms as possible alternate protein sources, motivated by large increases in the price of conventional animal feed. It was during this period that the term single cell protein (SCP) was first coined at the Massachusetts Institute of Technology. SCP is not pure protein, but refers to the whole cells of bacteria, yeasts, filamentous fungi or algae, and also contains carbohydrates, lipids, nucleic acids, mineral salts and vitamins.
In microbial SCP protein production, several natural products have been tested. The use of natural cheap substrates and waste industrial products for cultivating microorganisms appear to be general trend in studies of applied nature [1, 3]. For the same purposes Haider and EL-Hassy (2000) tested date extract supplemented with nitrogen source as a suitable substrate whereas, cashew and apple juice was used by Osho (1995) [3].

Microorganisms used as SCP
Bacteria
Bacteria have various essential characteristics that make it for uses as SCP, mainly rapid growth, short generation time. Growth on raw material which are readily available [4]. Some examples are *Brevibacterium* [5]. *Methylophilus methylitropous, Acromobacter delvaevate, Acinetobacter calcoacenticus, Aeromonas hydrophilla, Bacillus megaterium, Bacillus subtilis* [6], *Lactobacillus* species, *Cellulomonas* species, *Methylomonas methylotrophus* [7], *Pseudomonas fluorescens, Rhodopseudomonas capsulate, Flavobacterium* species, *Thermomonospora fusca* [8].

Mushrooms
Certain mushrooms and other fruiting bodies of filamentous fungi are edible and provide a good source of protein, whereas others have narcotic effects and some are highly toxic. A wide range has been traditionally used for food, but relatively few are grown commercially. In fact, of the hundreds of species that is edible, only about 10 are produced in any quantity. Mushroom production involves controlled non-axenic solid substrate fermentation. It is currently the only economically viable product from lignocellulose fermentation. Exploitation of such fruiting fungi for the generation of edible biomass has several advantages:

1. They represent examples of the most efficient conversion of plant wastes into edible food;
2. unlike many other single cell proteins, they are directly edible and many are considered to be food delicacies because of their characteristic texture and flavor;
3. harvesting of fruiting bodies is the easiest possible method of separating edible biomass from the substrate in a solid-state fermentation; and
4. Compared with animal sources of protein, many have far superior protein conversion efficiency per unit of land and per unit of time.

Agaricus bisporus
In Europe and the USA Agaricus *bisporus* (button mushroom) accounts for over 90% of total mushroom production value. Agarics are decomposers of cellulosic materials and are naturally found in meadows and woodlands, where they degrade plant debris. They are grown commercially in temperate regions using a substrate of composted straw. A crop is produced within 6 weeks, whereas other mushrooms may take several months or even years to fruit. A closely related species, *Agaricus bitorquis*, is also grown in some areas. It is less prone to certain viruses and the bacterial blotch disease of mushrooms, caused by *Pseudomonas tolaasii*.

The *Agaricus* Production Involves the Following Stages

1. Inoculum preparation: growth of spawn (inoculum) on sterilized cereal grains.
2. Solid-substrate preparation: composting of straw, manure and fertilizers at 60–70°C for 2 weeks.
3. Substrate 'sterilization', so-called 'peak heating' of compost for 5–7 days.
4. Spawn inoculation into 'sterilized' compost and mycelial growth, referred to as a 'run' at 25°C for 2–3 weeks.
5. Application of a casing (covering) layer of peat and chalk over the substrate.
6. Fruiting body production, fructification, in about four flushes (successive crops) over a period of 4–6 weeks.

SCP can be produced from High Energy Sources

Alkanes, methane, ethanol, methanol, gas oil generally bacteria and yeasts are employed.

Pekilo: a fungal protein rich product *Paecilomyces variotii* is used for production of Pekilo protein was produced by fermentation of wastes such as molassess, whey, sulfite liquor and agricultural wastes.

Quorn: Mycoprotein for humans Produced by *Fusarium graminearum*; It is dried and artificially flavoured and marketed in pieces that resemble beef, pork and chicken. Rich in essential nutrients and good content of dietary fibre.

Advantages of Production of SCP

1. 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) [9].
2. They can be easily genetically modified for varying the amino acid composition [10].
3. A very high protein content 43–85% in the dry mass.
4. They can utilize raw materials as carbon sources, which include even waste products. Thus, they help in the removal of pollutants also [11].
5. Strains with high yield and good composition can be selected or produce relatively easily [11].
6. Solar energy conversion efficiency can be maximized and yield can be enhanced by easy regulation of physical and nutritional factors [12].
7. Algal culture can be done in space that is normally unused and so there is no need to compete for land [12].

Disadvantages of Single Cell Protein

There are following disadvantages of using microorganisms as single cell protein.

1. Certain microorganisms produce toxic substances harmful to the human and animals.
2. SCP leads to indigestive disorders, allergic to humans, animals.
3. High level of nucleic acid content in microbial biomass will lead to kidney stone formation, skin, and intestinal problems.
4. May lead to carcinogenic.
5. Single cell protein production is a very expensive.

Conclusion

Large-scale development of SCP processes worldwide, has shown great to advancement in the areas of microbiology and biotechnology. Research and development into SCP processes has involved collaborative work in the fields of microbiology, biochemistry, genetic engineering, chemical and process engineering, food technology, agriculture, animal nutrition, ecology, toxicology, medicine and veterinary science and economics. The future of SCP production mainly depends upon reducing SCP production costs and improving in the quality of proteins. This will be achieved by lowering feedstock costs, advanced fermentation processes, applied genetics and recombinant DNA technologies. There are various limitations for the SCP production, the main limitations of SCP products are not becomes popular than conventional sources of proteins. In India, the people mentality will be major cause for use of SCP products. There is need for research and development will for usage of microbial substances as a single cell protein or as diet supplement in developing countries.

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