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Single Cell Protein:- A Review

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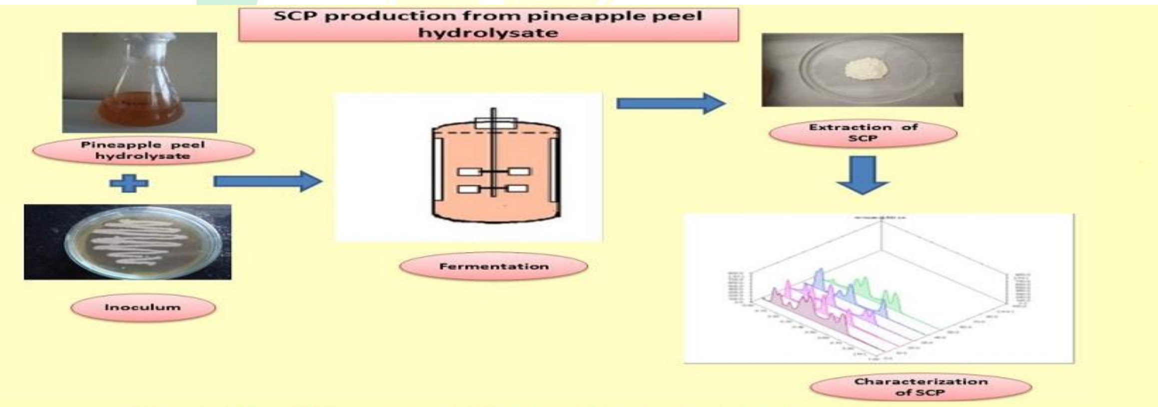
Introduction

Single-cell protein (SCP) refers to the microbial cells or total protein extracted from pure microbial cell culture (monoculture) which can be used as protein supplement for humans or animals. The word SCP is considered to be appropriate, since most of the microorganisms grow as single or filamentous individuals. This is in contrast to complete multicellular plants and animals.



Single Cell Protein Production in pineapple peel by *Saccharomyces cerevisia*

If the SCP is suitable for human consumption, it is considered as food grade. SCP is regarded as feed grade, when it is used as animal feed supplement, but not suitable for human consumption. Single-cell protein broadly refers to the microbial biomass or protein extract used as food or feed additive. Besides high protein content (about 60-80% of dry cell weight), SCP also contains fats, carbohydrates, nucleic acids, vitamins and minerals. Another advantage with SCP is that it is rich in certain essential amino acids (lysine, methionine) which are usually limiting in most plant and animal foods. Thus, SCP is of high nutritional value for human or animal consumption.

It is estimated that about 25% of the world's population currently suffers from hunger and malnutrition. Most of these people live in developing countries. Therefore, SCP deserves a serious consideration for its use as food or feed supplement. In addition to its utility as a nutritional supplement, SCP can also be used for the isolation of several compounds e.g. carbohydrates, fats, vitamins, minerals.

Advantages

- The SCP is rich in high quality protein and is rather poor in fats, which is rather desirable.
- They can be produced all the year round and are not dependent of the climate (except the algal processes).
- Some SCPs are good sources of vitamins, particularly B-group of vitamins, as well, e.g.. yeasts and mushrooms.
- Mushrooms are considered as delicacy in the human diet.
- At present, SCP appears to be the only feasible approach to bridge the gap between requirement and supply of proteins.
- They use low cost substrates and, in some cases, such substrates which are being wasted and causing pollution to the environment.
- The microbes are very fast growing and produce large quantities of SCP from relatively very small area of land.
- They use low cost substrates and, in some cases, such substrates which are being wasted and causing pollution to the environment.

As compared with traditional methods of producing proteins for feed or human foods, large scale production of the microbial biomass includes the following advantages:

1. Microorganisms have high rate of multiplication.
2. Microbes possess high protein content.
3. They can utilize large number of carbon sources.
4. Strains with high yield and good composition are produced easily.
5. Microbial biomass does not depend on seasonal and climatic variation.

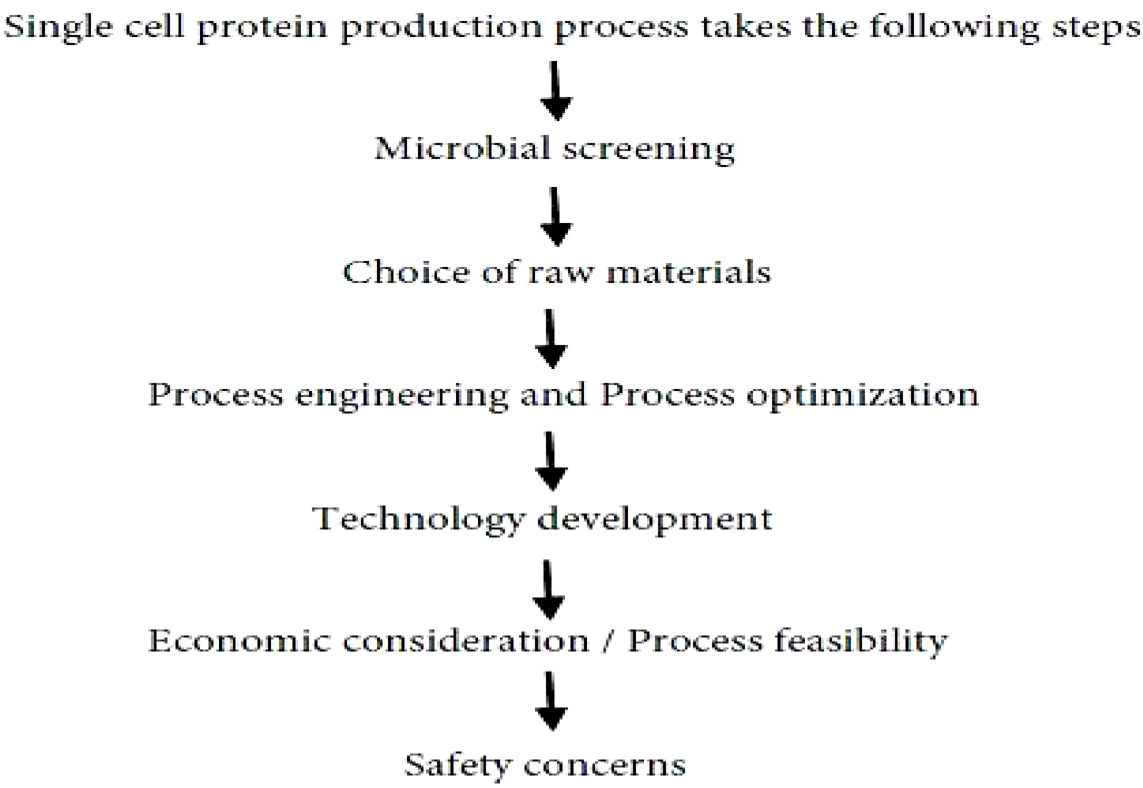
Economic Aspects

Development of SCP processes has always been driven by a need for protein, and this continues to be an important driver in the development of both old and new processes. The valorization of readily available substrate and waste streams has also been a strong driver and continues to be so. SCP is frequently seen as a potential co-product that could strengthen the economic potential of an otherwise unprofitable bio refinery process, as well as a means of reducing the downstream processing costs required to dispose of process waste. Selling residual biomass as feed is preferable to selling as fertilizer. This is seen in the numerous publications and patents (not addressed in this review) in which specific waste products are converted to SCP and are assessed as food for specific animals. However, environmental concerns also now play a strong role in driving the development of novel SCP products. This is seen particularly in the processes which utilize greenhouse gases: algal SCP from CO2 and bacterial SCP from methane. Such processes are unlikely to be economically viable in the short term, since there are still many problems to overcome in large scale cultivation, but may survive where they are able to benefit from a green premium. In addition, environmental concerns, as well as economic concerns, are helping to drive the development of products from waste streams.

Apart from the environmental benefits, the key elements in estimating the economic viability of a SCP production process are total product cost, capital investment and profitability. Ugalde and Castrillo (2002) estimated that in fungal SCP production 62% of the total product cost would come from the raw material and 19% from the production process. According to Aggelopoulos et al. (2014), raw material costs vary from 35 to 55% of the manufacturing costs, whereas the operation costs, including labour, energy, and consumables take 45–55%. Utilizing side-streams and waste biomass is sometimes viewed as a means to reduce the substrate costs, in cases when the substrate does not compromise the usability of the final product.

Scale is also important to the economic viability of SCP production. An empirical relationship exists between cost and scale of production. operations have been proven to be the most profitable ones and the majority of the SCP processes which have been implemented at industrial scale have been adjusted to continuous design (Ugalde and Castrillo, 2002). On the other hand, small scale, household production of some products may become feasible, in much the way that home yoghurt production or mushroom production has, and as has been suggested for plant cell nutrition without plants (Poutanen et al., 2017).

Flow chart of single cell protein.



Single Cell Protein (SCP) offers an unconventional but plausible solution to this problem of protein deficiency being faced by the entire humanity A list of the microorganisms used for the production of Single Cell Protein is as follows:

Fungi

- *Aspergillus fumigatus*
- *Aspergillus niger*
- *Rhizopus cyclopean*

Yeast

- *Saccharomyces cerevisiae*
- *Candida tropicalis*
- *Candida utilis*

Algae

- *Spirulina (spa)*
- *Chlorella pyrenoidosa*
- *Chondrus crispus*

Bacteria

- *Pseudomonas fluorescens*
- *Lactobacillus*
- *Bacillus megaterium*

Here are the average compositions of the different microorganisms present in the % dry weight of Single-cell protein.

Composition	Fungi	Algae	Yeast	Bacteria
Protein	30-45	40-60	45-55	50-65
Fat	2-8	7-20	2-6	1-3
Ash	9-14	8-10	5-10	3-7
Nucleic Acid	7-10	3-8	6-12	8-12

Substrate	Microorganism		
Food waste, Petroleum by-products, Natural gas	Bacteria	Fungi	Yeast
Lactose	*Aeromonas*	*Aspergillus*	*Amoco*
n-Alkane	*Achromobacter*	*Cephalosporium*	*Candida*
Methanol	*Acinetobacter*	*Chaetomium*	*Saccharomyces*
Ethanol	*Bacillus*	*Penicillium*	*Trichoderma*
Hemicellulose	*Flavobacterium*	*Rhizopus*	*Kluyveromyces*
Cellulose	*Lactobacillus*	*Scytalidium*	*Thermomyces*
Maltose	*Methylomonas*	Trichoderma	*Methylomonas*
Glucose	*Pseudomonas*	*Fusarium*	*Rhodotorula*
Galactose	*Rhodopseudomonas*		*Trichosporon*
Pentose			*Mucor*
Uric acid and other nonprotein nitrogenous compounds			

Disadvantages of Single-Cell Protein

In spite of many advantages, there are few drawbacks. Single-Cell Protein has not been widely accepted for human consumption owing to certain problems as follows:

- High level of nucleic acid in biomass makes it difficult for consumption as it may lead to gastrointestinal problems.
- The biomass may trigger an allergic reaction if the digestive system recognizes it as a foreign product.
- The presence of nucleic acids in high content leads to elevated levels of uric acid.
- In certain cases, the development of kidney stone and gout if consumed in high quality.
- Possibility of the presence of secondary toxic metabolites which results in Hypersensitivity and other skin reactions.
- The capital cost of production is high as sophisticated machinery is required.

Conclusion

Single cell protein (SCPs) with rich protein (60-70%) with a high concentration of vitamins B complex and low-fat values are suitable for human and animal consumption. The use of SCP as food ingredient is still in stages of development. There are a lot of prospects concerning improvement of using SCP in various means. Genetic engineering could enhance the synthesis of SCP with huge yield with no toxic by-products produced with the SCP. The application of agro-industrial waste in bio-processes such as cultivation of SCP provides a solution to the pollution problems. Further research and development will facilitate the usage of SCP as a supplement in diet in developing and underdeveloped countries to fight against malnutrition.

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