Single cell protein (SCP) is not pure protein (Table 1), but refers to the whole cells of bacteria, yeasts, filamentous fungi or algae, and also contains carbohydrates, lipids, nucleic acids, mineral salts and vitamins. It has several advantages over conventional plant and animal protein sources, which include:

1. rapid growth rate and high productivity;

2. high protein content, 30–80% on a dry weight basis;

3. the ability to utilize a wide range of low cost carbon sources, including waste materials;

4 .strain selection and further development , as these organisms are amenable to genetic modification;

5. the processes take little land area;

6. production is independent of seasonal and climatic variations;

7. consistent product quality.

Table 1: Protein and nucleic acid content in microorganisms

Microbe	Protein percentage	Nucleic acid
Bacteria	50–85	10–16%
Yeast	45–55	5–12%
Filamentous fungi	30–55	3–10%
Algae	45–65	4–6%

Note: soya beans contain approximately 40% protein.

The protein content and quality is largely dependent on the specific microorganism utilized and the fermentation process .
Fast-growing aerobic microorganisms are primarily used due to their high yields and high productivity. Bacteria generally have faster growth rates and can grow at higher temperatures than yeasts or filamentous fungi, and normally contain more

protein. Yeasts grow relatively rapidly and, like bacteria, their unicellular character gives somewhat fewer fermentation problems than do filamentous organisms. However, many filamentous fungi have a capacity to degrade a wide range of materials and, like yeasts, can tolerate a low pH, which reduces the risk of microbial contamination. They are also more easily harvested at the end of fermentation than yeasts or bacteria.
Selection of a suitable microbial strain for SCP production must take several characteristics into account, including:

1. Growth rate, productivity and yields on the specific, low-cost, substrates to be used;

2. Temperature and pH tolerance;

3. Oxygen requirements, heat generation during fermentation and foaming characteristics;

4. Growth morphology and genetic stability in the fermentation;

5. Ease of recovery of SCP and requirements for further downstream processing;

6 .structure and composition of the final product, in terms of protein content, amino acid profile, RNA level, flavor, aroma, color and texture.

Other major factors are safety and acceptability. Most SCP products are used as animal feed and not for human consumption. These products must meet safety requirements. Obtaining regulatory approval for the production of proteins for human consumption is an even lengthier and more expensive process, and obviously influences the choice of production organism.

A safety aspect that must be considered for all SCP products is nucleic acid content. Many microorganisms have naturally high levels, because fermentation conditions favoring rapid growth rates and high protein content also promote elevated RNA levels. This can be problematic as the digestion of nucleic acids by humans and animals leads to the generation of purine compounds.
Their further metabolism results in elevated plasma levels of uric acid, which may crystallize in the joints to give gout-like symptoms or forms kidney stones. Slow digestion or indigestion of some microbial cells within the gut and any sensitivity or allergic reactions to the microbial protein must also be examined.
An additional concern is the absorption of toxic or carcinogenic substances, such as polycyclic aromatic compounds, which may be derived from certain growth substrates.

Single cell protein production processes

The SCP production processes essentially contain the same basic stages of the carbon substrate or microorganism used.

1. Medium preparation.

The main carbon source may require physical or chemical pretreatment prior to use.

2. Fermentation.

Continuous fermentations are generally used, which are operated at close to the organism's maximum growth, to fully exploit the superior productivity of continuous culture.

3. Separation and downstream processing.

The cells are separated from the spent medium by filtration or centrifugation and may be processed in order to reduce the level of nucleic acids.

RNase activity is retained and degrades RNA to nucleotides that diffuse out of the cells.

Depending upon the growth medium used, further purification may be required, such as a solvent wash, prior to pasteurization, dehydration and packaging.

The physiological problems that are often encountered on scale-up include difficulties with:

1. Oxygen requirements and oxygen transfer rates;

2. Nutrient and temperature gradients;

3 .effects of CO_2, as high levels may inhibit respiration in certain microorganisms;

4. Hydraulic pressure in deep fermenters.

MICROORGANISMS USED IN SCP PRODUCTION

Organisms to be used in SCP production should have the following properties:

(a) Absence of pathogenicity and toxicity

(b) Protein quality and content: The amount of protein in the organisms should not only be high but should contain as much as possible of the amino acids required by man.

(c) Digestibility and organoleptic qualities

(d) Growth rate: It must grow rapidly in a cheap, easily available medium.

(e) Adaptability to unusual environmental conditions

Bacteria

Methanomones sp.
Methylococius capsulatus
Pseudononas sp.
Hyphomisobium sp. Mixed
Acinetobacter sp.
Flavobacterium sp.
Arthrobacter simplex
Nocardia paraffinica
Nocardia paraffinica

Mycobacterium phlei
Nocardia sp.

Fungi

Candida tropicals , Candida lipolytica ,Fusarium sp. and Aspergillus sp.