Chapter 7
Microalgae, SCP And Edible Mushroom

This chapter includes Microalgae, SCP and Edible mushroom. The importance of microalgae are they have a high protein and oil content, for example, which can be used to produce either biofuels or animal feeds, or both. In addition, microalgal biomass, which is rich in micronutrients, is already used for dietary supplements to advance human health. Single-cell protein (SCP) refers to protein derived from cells of microorganisms such as yeast, fungi, algae, and bacteria, which are grown on various carbon sources for synthesis. It is a protein source for human food supplements and animal feeds. Mushrooms are also very important they are rich in the B vitamins: riboflavin, niacin, and pantothenic acid. The combination helps protect heart health. Riboflavin is good for red blood cells. Niacin is good for the digestive system and for maintaining healthy skin.

Microalgae

Microalgae also called microphytes are microscopic algae, typically found in marine and fresh water systems living in water column and sediment. They are unicellular and exist individually or in groups or chains. Microalgae can be cultivated and are used to produce either biofuels or animal feeds. Microalgal biomass is rich in micronutrients is used as dietary supplement to improve human health. Apart from being a source of protein, presence of various bioactive components in microalgae provide an added health benefit. Compared to various plant and floral species, microalgae contain higher amounts of pigments. These pigments have anticarcinogenic, antioxidative and antihypertensive properties.

Microalgal derived proteins have complete Essential Amino Acids (EAA) profiles and their protein content is higher than conventional sources such as meat, poultry and dairy products. Numerous species of microalgae are reported to be rich in proteins, carbohydrates, lipids and other bioactive compounds. The Chinese people consumed *Nostoc* species of microalgae around 2000 years ago as food and later *Chlorella* and *Spirulina* species were consumed as functional healthy foods in Taiwan, Japan and Mexico. Currently the microalgae derived foods are marketed as healthy foods and are available in industry as capsules, tablets, powders and liquids. They are also mixed with candies, gums, snacks, pastes, noodles, breakfast cereals, wine and other beverages. The microalgae species widely used include *Spirulina plantesis*,

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Chlorella sp; *Dunaliella terticola, Dunaliella saline* due to their high protein content and nutritional value. However, in recent years, *Chlorella* and *Spirulina* species are dominating the global microalgae market as they are gaining popularity in the health-food supermarkets and stores. Similar to human supplementation, microalgae is also a source of food for many aquatic species, ruminants, pigs, poultry and other animals. *Chlorella* species are often marketed as 'healthy foods' and are being promoted as a functional foods to prevent, cure or help common diseases or acute diseases like Alzheimer's disease, cancer etc. *Chlorella* sp. are excellent hepatoprotective and hypocholersterolemic agents during malnutrition and ethionine intoxication, they lower blood sugar concentration and increase haemoglobin concentration. *Chlorella* also contains an active immunostimulator-β- 1,3- glucan, which reduces blood lipids and act as a free radical scavenger.

Spirulina sp; also known as **"Superfood**", a label given by World Health Organiszation belongs to the blue-green photoautotrophic genus of unicellular microalgae. It is an excellent natural source of vitamin A, B1, B2 and B12, essential fatty acids and useful pigments such as Xanthophyll and Carotenoids. Additionally various other minerals such as magnesium, manganese, and potassium are reported in small amounts. *Spirulina* is reported to lower LDL cholesterol and triglyceride levels, lower blood pressure and control blood sugar. Supplementation with *spirulina* is also reported to increase haemoglobin levels of red blood cells in older people and improve their immune system. The WHO recommended *spirulina* spp. to be added in diet of National Aeronautics and Space Administration (NASA) astronauts in Space as it is an ideal and compact food for Space Travel. It contains wide range of nutrients even when consumed in small amount.

Single cell Protein (SCP)

SCP also known as microbial protein. The term single cell protein refers to the total protein extracted from the pure cultures of microorganisms (yeast, algae, filamentous fungi, bacteria) and can be used as a protein-rich food supplements by humans and animals.

Production of SCP

Production of SCP involves the following steps

- Selection of strain of microbe and substrate
- Fermentation
- Harvesting
- Post harvest treatment
- Processing of SCP

Selection of strain of microbe and substrate

It is the very crucial step. The microbe selected for the production of SCP shouldn't produce toxicity in its biomass, should not harmful for a consumer to consume and should produce a large quality of protein.. The substrate used should be cheap, effective, allow favorable growth and should be ease of isolation.

Fermentation

Fermentation is done in a large chamber of either glass or stainless steel called 'fermentor'. Fermentation should be done under sterilized conditions and under controlled conditions (Temperature, pressure, pH, humidity etc). Fed-batch cultures are usually used for the fermentation of microbes.

Harvesting

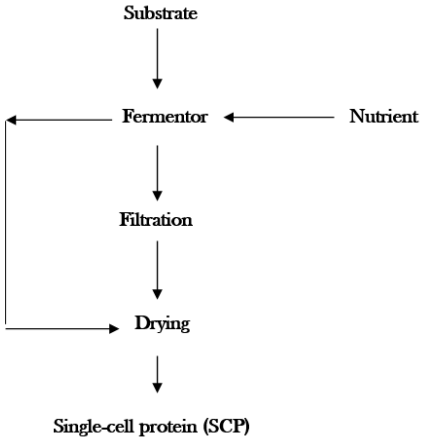
Fermentation yields larger number of microbial colonies from single cell. These colonies are isolated from individual cell by the method of "Decantation".

Post – harvesting fermentation

Isolated microbial colonies are subjected to various differential techniques namely centrifugation, washing, drying etc.

Processing of SCP

The protein produced may contain impurities in it (carbohydrates, nucleic acids, lipid contents, salts etc.). The isolation of pure protein can be achieved by disrupting the cell wall through crushing, crumbling, cycles of freezing and thawing, grinding and thermal shocks. The removal of nucleic acids are done by treatments with 10% NaCl, by chemicals eg: NaOH, by thermal shocks or by enzyme treatment eg: ribonucleases.



Flowchart for the production of SCP

Advantages of SCP

- Microbes can use a variety of raw materials as their source of carbon and thus can cause the removal of pollutants from the environment.
- They contain 43-85% of protein contents in their dry mass
- They can be easily modified genetically for varying the amino acid composition
- Microbes have rapid succession of generation thus number of generation can be obtained in a very short interval of time (algae 2-6 hrs, yeast 1-3 hrs, bacteria 0.5-2 hrs).

Disadvantages of SCP

- Some microbes are harmful for both humans and animals and can produce toxins in their biomass which may cause diseases in humans and animals.
- Microbial biomass may lead to some allergic reactions and indigestion
- The higher nucleic acid contents in SCPs may lead to human kidney stone
- Taste may change and some unacceptable coloration may produce
- Production of SCP is very expensive method and requires highly sterilized conditions

Microorganisms used for SCP

Microorganisms that can be used for the production of SCPs are yeast, filamentous fungi, algae and bacteria.

Yeast

Saccharomyces cerevisiae

Pichia pastoris

Candida utilis

Torulopsis

Geortrichum candidum

Fungi (Mycoprotein)

Aspergillus oryzae

Fusarium venenatum

Sclerotium rolfsii

Polyporus

Trichoderma

Scytalidium acidophilum

Bacteria

Rhodobacter capsulatus

Pseudomonas sps.

Achromobacter deluacuate

Algue

Spirulina (Dietary Supplement)

Chlorella

Mushrooms

- Fast growing basidiomycetous fungi
- Produces fleshy fruit bodies
- May be button like, fan or umbrella shaped
- They are characterized by having heterotrophic mode of nutrition
- Rich in protein and other accessory compounds

Nutrients in Mushroom

Generally all mushroom are

- Low in sodium, fat and calories, just about 20 calories in a cup
- High in fiber and protein: 20-30% protein by dry weight
- Rich in the minerals potassium, selenium, copper, zinc and magnesium; Oyster mushroom is rich in iron too.
- Rich in B complex vitamins, riboflavin, niacin and pantothenic acid
- The only vegetable or fruit for that matter that produces vitamin D when in sunlight and is a source of natural vitamin D.
- Rich in L- ergothioneine, a powerful antioxidant
- Rich in cancer fighting nutrients like polysaccharides and linoleic acids
- Free of cholesterol
- Contain triterpenes which inhibit histamine release and are anti-inflammatory

Edible Mushroom

Edible mushrooms are the fleshy and edible fruit bodies of several species of macrofungi. According to Chang and Hayes:

- They can appear either below ground (hypogeous) or above ground (epigeous) where they may be picked by hand.
- Edible mushroom are consumed for their nutritional value and they are occasionally consumed for their supposed medicinal value.

Agaricus bisporus

- Edible basidiomycete mushroom native to grasslands in Europe and North America
- They may grow on the soil or on another food source
- China is the largest producer of edible mushrooms accounting for over 50% of the world's edible mushroom production.
- This mushroom may be known as common mushroom, button mushroom, white mushroom, cultivated mushroom, table mushroom and champignon mushroom.

Pleurotus citrinopileatus

- Golden oyster mushroom is an edible gilled fungus
- Is one of the most popular wild edible mushroom
- Grow in clusters of bright yellow to golden brown caps with a velvety, dry surface texture
- Caps range from 20-65 mm in diameter
- The flesh is thin and white, with a mild taste and without a strong smell
- The gills are white, closely spaced and run down the stem
- The spores are cylindrical or elliptical in shape, smooth, hyaline, amyloid and measure 6-9 by 2-3.5 micrometre.

Volvariella volvacea

- Also known as Paddy straw mushroom or straw mushroom
- It is a species of edible mushroom cultivated throughout East and Southeast Asia and used extensively Asian cuisines.
- They are often available fresh in Asia, but are most frequently found in canned or dried forms outside their nations of cultivation.
- Straw mushrooms are grown on rice straw beds

- They are adaptable and take four-five days to mature and are most successfully grown in subtropical climates with high annual rainfall.

Common edible mushrooms

White or Button (*Agaricus bisporus*)

A creamy white to pale tan color, these mushrooms have a firm texture and delicate flavor. They are juicy, tasty and inexpensive. They can be grilled or mixed with other mushrooms, can also be stuffed and baked.

Chanterelle (*Cantharellus cibaris, C. formosus etc.*)

A medium textured mushroom with fruity aroma. The color ranges from pale white to yellow to orange and brown to black. It has wrinkles on the underside instead of gills.

Oyster (*Pleurotus ostreatus*)

It has a velvet like texture and is trumpet shaped with colors ranging from grey to pale brown to reddish caps on grey white stems. It has a mild seafood taste.

Portobello (*Agaricus bisporus*)

It has a big, large, umbrella like cap. The texture and taste is steak like yet is butterfly soft.

Shiitake (*Lentinula edodes*)

The color of its cap ranges from tan to dark brown. It has an earthy, smoky flavor and tastes best when cooked. It is low in water content.

Cremini (*Agaricus bisporus*)

This is actually the immature Portobello, resembling the white mushroom but with a firmer texture and deeper flavor. The cap can be from a pale tan to rich brown color.

Enokitake (*Flammulina velutipes*)

A mild flavored, crunchy textured mushroom with a fruity taste.

Porcini (*Boletus edulis*)

It has a rich woody flavor, the cap can be roasted like the Portobello or it can be diced and cooked. It can be also added raw to salad.

Morel (*Morchella angusticeps, M. esculenta etc*)

It is considered a delicacy. It has a deep and clean flavor. It can be toxic if eaten raw and should therefore be cooked. It can be cooked with non fat cream sauces and tastes best with just a little amount of butter.

Black Truffles (*Tuber melanosporum, T. magnatum etc.*)

It has a sweet, musky and pungent flavor.

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