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Innovation The Research Concept

Production of Single Cell Protein (SCP) From Fermentation Process

Abstract

Metabolites and single cells protein are produced in more quantity by employing our study on industrial feasibility of facility and they are solely dependent upon the biomass accumulation at the end of each batch. The substrates are acid hydrolysed to produce glucose and the fermentation process and is carried out at 37°C. Single Cell Protein (SCP) is a microbial biomass products and produced by fermentation processes. SCP production technologies development is a promising way to solve the problem of worldwide protein shortage. SCP has evolved as bioconversion processes which turned low value by-products, often wastes, into products with added nutritional and market value. Fermentation science and technology for biomass production has resulted in a profound body of knowledge and a lot the benefits now has span the field of SCP production. Application of plant breeding programmes and agricultural crop production techniques has caused best resulted in a high availability of plant food sources, such as soya, maize, wheat and rice in the second half of the 20th century.

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Introduction

Political and economic developments has controlled the world order from a system of blocks to globalisation and provided the facilitation of the open trade of agricultural products. Agricultural products have out marketed SCP on the grounds of lower price. The combination of sophisticated production with food processing technology hs yielded a new generation of SCP products which could function as meat substitutes, texture providing agents and flavour enhancers. It has shown diverse application of heterologous protein expression to further develop the potential food line, resulting in precisely tailored products and meet specific dietary requirements, or simulate high added value specialty products (Ugaldea, and Castrillo, 2002).

Single-cell proteins are obtained from dried cells of microorganism and are good protein supplement in human foods or animal feeds. There are many microorganisms like algae, fungi, yeast and bacteria which have utilized inexpensive feedstock and wastes as sources of carbon and energy for growth to produce biomass, protein concentrate or amino acids ((Wang et al., 2014). We have obtained single cell protein as natural protein concentrate as protein accounts for the quantitatively from microbial cells. With increase in population and worldwide protein shortage the use of microbial biomass as food and feed, it is best proteins sources. The high rate oxidation pond (i.e. a particularly intensive type of pond) has produced on the average 34 g/m27sol;day solids, or over 100 tons/ha (hectare) annually. And two clarification routes have been found promising such as centrifugation and alum flocculation followed by frothflotation. It is less expensive in terms of both fixed and operating cost, and gives clarified effluent of higher quality, which can be seasonally stored with minimal eutrophication because the aluminum removes most of the phosphate from the effluent. A good product has been obtained by drum-drying the concentrate, and preliminary feeding tests have indicated that it can replace at least 1/4 of the soymeal in broiler rations and 2/3 of the fishmeal in carp feed (Nasseri et al., 1979)

Although single cell protein has provided the high nutritive value due to higher protein, vitamin, essential amino acids and lipid content. It to be replaced to the conventional protein sources due to their high nucleic acid content and slower in digestibility. Cell proteins have application in animal nutrition as: fattening calves, poultry, pigs and fish breading (Yunus et al., 2015). In food it is used as: aroma carriers, vitamin carrier, emulsifying aids and to improve the nutritive value of baked products, in soups, in ready-to-serve-meals, in diet recipes and in the technical field in:

paper processing, leather processing and as foam stabilizers. The production of SCP from various microbes has been studied but focus has been on fungi and bacteris and more recently on microalgae (Mahasneh, 1997). Algal proteins are of high quality and comparable to conventional vegetable proteins. However, due to high production costs as well as technical difficulties, cultivation of algae as protein is still in evaluation Because of the high celluloid content in cell wall i.e., nearly 10% dry weight its human digestibility is almost not possible poses a serious problem (Rasoul-Amini *et al*., 2009). Hence, effective treatments are necessary to disrupt the cell wall to make the protein and other constituents accessible for digestive enzymes. Several authors have studied the effect of different post-harvesting treatments on the digestibility of various algal species. Different species of algae, fungi, yeasts and bacteria are used as single cell protein and produced at commercial scale. These organisms are grown on different carbon source**s** (Becker, 2007).

Yeast cells have been considered as a substitute because of their small particle size, high protein content as SCP and relatively low production costs. However, poor digestibility may be an important constraint in the use of this SCP as a food source in **seed production** of aquacultural organisms, since yeast has a complex and thick cell envelope. The external mannoprotein layer of the yeast cell wall is probably the major barrier to digestion ((Kim *et al*., 1998)).

Table 1 Microorganism And Substrates Is Used For Single Cell Protein Production , (Bhalla et al. 2007)

Microorganism	Substrate
Bacteria	
Aeromonas hydrophylla	Lactose
Acromobacter delvacvate	n-Alkanes
Acinetobacter calcoacenticus	Ethanol
Bacillus megaterium	Non-protein nitrogenous compounds
Bacillus subtilis, Cellulomonas sp., *Flavobacterium* sp., *Thermomonospora fusca*	Cellulose, Hemicellulose
Lactobacillus sp.	Glucose, Amylose, Maltose
Methylomonas methylotrophus, M. clara	Methanol
Pseudomonas fluorescens	Uric acid and other non-protein nitrogenous compounds
Rhodopseudomonas capsulata	Glucose
Fungi	
Aspergillus fumigatus	Maltose, Glucose
Aspergillus niger, A. oryzae, *Cephalosporium eichhorniae, Chaetomium cellulolyticum*	Cellulose, Hemicellulose
Penecillium cyclopium	Glucose, Lactose, Galactose
Rhizopus chinensis	Glucose, Maltose
Scytalidium aciduphlium, Thricoderma viridae, Thricoderma alba	Cellulose, pentose
Yeast	
Amoco torula	Ethanol
Candida tropicalis	Maltose, Glucose
Candida utilis	Glucose
Candida novellas	n-alkanes
Candida intermedia	Lactose
Saccharomyces cereviciae	Lactose, pentose, maltose
Algae	
Chlorella pyrenoidosa, Chlorella sorokiana, Chondrus crispus, Scenedesmus sp., *Spirulina* sp., *Porphyrium* sp.	Carbone dioxide through photosinthesis

The substrates which have been used for SCP production by yeasts so far include sorghum hydrolysate, sulfate waste liquor, pawn-shell wastes, dairy wastes, methanol, molasses, starch and plant origin liquid waste. Several fungi like *Fusarium oxyporum* var., *lini* and *Chetomium cellulolyticum*, algae like *Chlorella* and *Spirulina*, yeast like *Candida lipolytica* and *Saccharomyces sereviciae* and phototrophic bacteria like *Rodospirillum* sp., have been used. Yeast cells have been considered as a substitute because of their small particle size, high protein content as SCP and relatively low production costs. However, poor digestibility may be an important constraint in the use of this SCP as a food source in seed production of aquacultural organisms, since yeast has a complex and thick cell envelope (Humphrey, 1975).

Methods of Cell Wall Destruction

The use of microorganism for refined SCP is required an adequate amount of specific organism with disruption of the cell wall by an efficient technique. For disruption of cell, mechanical integration of cell wall is carried out by crushing, crumbling, grinding, pressure homogenization or ultra sonification. Various enzymes or combination of enzymes are also used to digest and disrupt cell wall, either partially or completely. It has shown the enzymatic hydrolysis of cell wall as attractive methods act on its delicacy and specificity for only the cell wall structure. It can be used as an alternative to the mechanical disruption, especially for materials and inactivated it during the mechanical process (Damodaran and Kinsella, 1983). And enzymatic hydrolysis can be performed by endogenous or exogenous enzyme from other microorganisms. Extensive enzymatic lysis of cells found very slow process compared to mechanical disruptions. It is possible to use two or more methods for cell disruptions. Combined mechanical and enzymatic degradation of yeast cell wall was tested by . In case of yeast cells they first can be mechanically broken and then incubated with a lytic enzyme. It causes the release of a substantial amount of protein mostly from organelles and cell walls (Asenjo and Dunnill, 1981).

Non-Mechanical Methods

1. Chemical treatment: acid, base, solvent, detergent; Enzyme analysis: lytic enzymes, phage infection, autolysis
2. Physical treatment: freeze-thaw, osmotic shock, heating and drying

Mechanical Methods

1. High pressure homogenization and Wet milling
2. Sonification and Pressure extrusion: french press, freeze pressing
3. Decompression (pressure chamber) and Treatment with grinding particles

Raw Material And Growth Medium

Wood can be also cooked in a medium containing calcium sulfite with excess free sulfur dioxide. Lignin is thus converted to lignosulfonates and hemicellulose is hydrolysed to monosaccharides and may be further broken down to furfurols. The amount of free sugars in the spent liquor is variable with the type of procedure chosen, as various cellulose fibers may be obtained with different degrees of degradation. The first organism to be used was *Saccharomyces cerevisiae*, although this organism is unable to metabolise pentoses which are found in considerable amounts in this waste product. Other organisms better suited for the assimilation of all the sugar monomers were chosen, namely *Candida tropicalis* and *Candida utilis*. Yeast produced from sulfite liquor has been used for feeding at war periods, but lost favour in peace time. However, experiences of baker's yeast produced from sulfite liquor exist in Finland by Peliko process (Selima et al., 1991).

Nutritional Requirements

Most strain can grow aerobically on glucose, maltose, and trehalose and fail to grow on lactose and cellobiose. However, growth on other sugars is variable. Galactose and fructose are shown to be two of the best fermenting sugars. The ability of yeasts to use different sugars can differ depending on whether they are grown aerobically or anaerobically. Some strains cannot grow anaerobically on sucrose and trehalose. All strains can use ammonia and urea as the sole nitrogen source, they can also use amino acids at times but cannot use nitrate, since they lack the ability to reduce them to ammonium ions. *S. cerevisiae* does not excrete proteases, so extracellular protein cannot be metabolized. Yeasts also have a requirement for phosphorus, which is assimilated as a dihydrogen phosphate ion, and sulfur, some metals, like magnesium, iron, calcium, and zinc, are also required for good growth of the yeast (Prado-Rubio et al., 2010).

Advantages of Using Microorganisms for SCP Production

The protein-producing capabilities of a 250 kg cow and 250 g of microorganisms have been compared. Cow can produce about 200 g protein per day where as microorganisms can produce about 20-25 tonnes of protein by growing under ideal conditions by theoretically. We have estimated that around 25% of the world's population is currently suffering from hunger and malnutrition most of developing countries. And SCP is deserve 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.

Limitation of SCP Uses

SCP from fungal origin has been used as a source of protein but its nucleic acid content, as well as its deficiencies in sulfur containing amino acids has render it as a food factor which need formulation along with other compensating sources of protein. In most cases, yeast and fungal SCP has been included in animal feeds with excellent results, and it is normally accepted that a 10% contribution of this product in mixtures with other sources providing carbohydrates, lipids and vitamins, is acceptable. Yeast protein is most commonly included in poultry food formulations. A compromise method which is effective consists of incubation at pH 9.5m followed by a heat shock which precipitates the protein. Sodium chloride extraction follows. In some yeast products, thermal shock at 60°C is applied followed by pancreatic ribonuclease, reducing the nucleic acid content from 9% to 2%. Similar results have been achieved by a series of short heat bursts which activate intracellular ribonucleases in yeast. Toxicological tests taking into account aspects other than RNA content, such as allergenicity and mutagenicity, show that SCP is an acceptable product in the case of yeasts

Conclusions

Single cells proteins are produced at industrial feasibility level and it is dependent upon the biomass accumulation at the end of each batch. The complex substrates are go for acid hydrolysis to produce glucose as raw and carbon source during fermentation process and are carried out at 37°C. Single Cell Protein (SCP) is a result of microbial biomass product and produced at large quantity by fermentation processes. SCP production technologies development has help a lot to solve the problem of worldwide protein shortage. SCP has developed as bioconversion processes which is obtained from low value by-products, often wastes, into products with added nutritional and market value. Fermentation technology has worked a lot and resulted good for biomass production in a profound body of knowledge and a lot the benefits. It has now span the field of SCP production to get large quantity. A lot of waste product are available in our county and it has shown high availability of plant food sources, such as soya, maize, wheat and rice in the second half of the 20th century for use as raw material for SCP production.

References

1. *Ugaldea, U.O., Castrillo, J.I., 2002. Single cell proteins from fungi and yeasts. Applied Mycology and Biotechnology, 2: 123-149.*
2. *Moraine, R., Shelef, G., Meydan, A., Levi A., 1979. Algal single cell protein from wastewater treatment and renovation process. Biotechnology and Bioengineering , 21(7): 1191–1207.*
3. *Wang, H., Deng, H., Ma, L., Ge L., 2014. The effect of carbon source on extracellular polymeric substances production and its influence on sludge floc properties. Journal of Chemical Technology and Biotechnology, 89(4): 516–521*
4. *Nasseri, A.T., Rasoul-Amini, S., Morowvat M.H., Ghasemi, Y., Single Cell Protein: Production and Process. American Journal of Food Technology, 6: 103-116.*
5. *Yunus, F-N., Nadeem, M., Rashid, F., 2015. Single-cell protein production through microbial conversion of lignocellulosic residue (wheat bran) for animal feed. Inst. Brew.; 121: 553–557*
6. *Mahasneh, I.A., 1997. Production of single cell protein from five strains of the microalga Chlorella sp. (Chlorophyta). Cytobiosciences, 90: 153-161.*
7. *Rasoul-Amini, S., Y. Ghasemi, M.H. Morowvat and A. Mohagheghzadeh, 2009. PCR amplification of 18S rRNA, single cell protein production and fatty acid evaluation of some naturally isolated microalgae. Food Chem., 116: 129-136.*
8. *Becker, E.W., 1994. Microalgae: Biotechnology and Microbiology. Cambridge University Press, Cambridge, UK.*
9. *Kim, J.K., K.T. Tak and J.H. Moon, 1998. A continuous fermentation of Kluyveromyces fragilis for the production of a highly nutritious protein diet. Aquac. Eng., 18: 41-49.*
10. *Humphrey, A.E., 1975. Product Outlook and Technical Feasibility of SCP. In: Single Cell Protein II, Steven, R., S.R. Tannenbaum and D.I.C. Wang (Eds.). MIT Press, Cambridge, MA., pp: 1-23.*
11. *Bhalla, T.C., N.N. Sharma and M. Sharma, 2007. Production of Metabolites, Industrial Enzymes, Amino Acid, Organic Acids, Antibiotics, Vitamins and Single Cell Proteins. National Science Digital Library, India.*
12. *Damodaran, S. and J.E. Kinsella, 1983. The use of chaotropic salts for separation of ribonucleic acids and proteins from yeast nucleo-proteins. Biotechnol. Bioeng., 25: 761-770.*
13. *Asenjo, J.A. and P. Dunnill, 1981. The isolation of lytic enzymes from Cytophaga sp. and their application to the rupture of yeast cells. Biotechnol. Bioeng., 23: 1045-1056.*
14. *Selima, M.H., Elshafeia A.M., El-Diwany, A.I.,1991. Production of single cell protein from yeast strains grown in Egyptian vinasse. Bioresource Technology, 3(62): 157-160.*
15. *Prado-Rubio A., BagterpJørgensen, J., BayJørgensen, S., 2010. Systematic Model Analysis for Single Cell Protein (SCP) Production in a U-Loop Reactor. Computer Aided Chemical Engineering, 28: 319-324.*