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YEASTS AS A SOURCE OF SINGLE CELL PROTEIN PRODUCTION : A REVIEW

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ABSTRACT

More than twenty years ago, biological systems, including systems, were used microbes such as bacteria, fungi, algae, and yeasts in the production of Single Cell Protein, due to the ability of these systems to carry out a wide range of biochemical reactions and easily adapt to different environmental conditions, It enables them to benefit from sources cheap carbon. It is important to produce proteins Single-celled being cheaper at the level commercial and its production depends on industrial waste Agricultural, It is not affected by climatic changes and natural disasters, In addition to the possibility of producing large quantities of it. In a short time compared to the traditional methods of production Vegetable and animal protein.

***Keywords*:** Yeasts, Single Cell Protein, Production.

Introduction

Biotechnology is defined as the totality of processes that use biological systems and living organisms or their components to produce, alter or develop products or processes for specific uses that are of value and benefit to humans in various fields by increasing crop production, disease resistance, food, and drug production, environmental improvement, and others (Steinhäusler, 2011) microorganisms can be a chemical plant that, under certain and specific conditions, can produce hundreds of food, industrial, and medical products as a result of the chemical changes they bring to some raw materials (Walsh, 2007). Before embarking on the use of microorganisms in production of any products, the organism must be capable of producing the economic product in addition to the appropriate environment must be available (the raw material that the organism is working on).

One of the problems facing the modern world is a large food shortage that may affect the growth and health of children, especially in developing countries, therefore, the researchers turned their attention to trying to find inexpensive food sources such as single cell protein by developing micro-organisms such as bacteria, fungi, yeasts and algae that are characterized by their rapid growth on waste and inexpensive materials such as residues of different products and industries(Nangul and Bhatia, 2013).

A Single Cell Protein is a dried cell of microorganisms that is used as a food supplement of protein in human foods or animal feed. This type of protein is cheap and strongly competes with other protein sources, and can also provide good nutritional value. In addition to the high protein content, which ranges between 60-82%,ingle-cell protein contains fats, carbohydrates, Vitamins, and minerals (Jamel *et al*., 2008), It is also rich in essential amino acids such as lysine and methionine which most plants and animal feed are missing (Mondal *et al*., 2012).

The Foundations for Choosing Microorganism

1. Not to be a disease-causing or poisonous species.
2. Protein synthesis is of a special nature and acceptable when consumed as food.
3. The microorganism gives an abundant amount of protein and is of good nutritional quality, That is, it has high values of the total protein benefit or nitrogen retention and protein efficiency ratio.
4. High growth speed and does not require high-cost agricultural media.

Yeasts Used to Produce Single Cell Protein

The first to use the term single cell protein which means yeast cells developing on waste and containing a high proportion of protein is Professor Carol Winston in 1966 instead of the word previously used microbial protein (Vasile *et al*., 2000). Single cell protein was produced by yeast *Sacharomyces cerevisiae* in Germany during World War I and molasses were used as a source of carbon and ammonium salts as a nitrogenous source. Yeasts are often used in human food, but today it is used in animal feed as a protein source to bridge the deficiency of soy and fish oil (Jaganmohan *et al*., 2013).

Many yeasts produce single cell protein and the following table shows the most important yeasts produced for single cell protein:

Table 1: Yeasts produced of single cell protein

Name of Yeats	Source
C. tropicalis	Abdul-Kareem*et al*., 2008
Candida sp.	Bozakouk, 2002
Candida utilis	Abdul-Kareem*et al*., 2008
Cryptococcus	Sengupta *et al.,* 2006
Hansenula	Tanveer, 2010
Lipomyces	Sengupta *et al.,* 2006
Pitchia	Tanveer, 2010
Rhodosporidium	Sengupta *et al.,* 2006
Rhodotorula	Sengupta *et al.,* 2006
Saccharomyce cerevisiae	Sharmaandkani,2017
Torulpsis sp.	Tanveer, 2010
Trichosporon	Sengupta *et al.,* 2006
Yarrowia	Sengupta *et al.,* 2006

The Importance of Production Single Cell Protein by Yeasts

Yeasts are the best organisms in the production of single cell protein and thus superior to microscopic bacteria and algae in the ease of harvesting and low content of nucleic acids and high protein content that constitutes 50% of the dry weight, as well as its ability to grow in different acid levels (Hamdy, 2013) and the resulting biomass Yeasts are relatively rich in amino acids compared to other traditional protein sources (Ugalde and Castrillo, 2005).

Experiments have proven the advantage of using yeasts from among the microorganisms to produce unicellular protein, especially from cheap carbon sources such as petroleum, including species *Candida* sp. which are used to support animal feed and thus turn into animal protein for human feeding, as using *C. utilis* due to its ability to use several carbon sources and support it to produce biomass high protein in addition to industrial products that are suitable for animal and human consumption and that these yeasts enter into their composition (Nigam, 2000). *S. cerevisiae* is very important for the production of single cell protein because of its greater size and ease of harvesting and containing less quantities of nucleic acids and the effective mix of amino acids and this is considered one of the solutions in the third world countries and developing countries that suffer from food shortages and malnutrition problems (Bacha and Nasir, 2011).

Substrates for Single Cell Proteins

There are many sources that a substrate can be used to grow microorganisms on, and these include three main types:

1. Energy sources or derivatives of these sources such as natural gas, gas oil, ethyl and methyl alcohol, acetic acid.
2. Waste like whey from cheese, sulfur, from paper, human and animal waste, sewer and CO_2.
3. Materials from plant sources such as starch, sugar, cellulose, molasses, and others.

The second group of these sources has received wide attention due to the little or no cost of their purchase and the world's concern for the health of the environment as polluting the environment as it is disposed of and working to not return to the environment in this way. These wastes can also be chemically reduced by CO to oil used as an energy source. (Suman *et al*., 2015).

When making protein, the processed protein must be subject to the general conditions of processed food, the most important of which is its health in terms of its absence of germs and toxins, and high quality control while focusing (Mondal, 2006).

Requirements for Single Cell Production

The technology of producing single cell protein has evolved over the past hundred years in a large way, and this technology requires providing some basic requirements for the purpose of conducting them, including:

1. Availability of a carbon source that requires prior physical or chemical treatment
2. Add some nutrients like phosphorous and nitrogen to get optimal growth for the selected microorganisms.
3. Alarge scale biomass fermenter.
4. Use sterilization to avoid contamination and to provide conditions for health conditions, sterilizing media components by heating or filtering, as well as sterilizing fermentation equipment.
5. Purify the selected microorganisms.
6. Provide adequate ventilation
7. Collect the biomass of the microscopic organism from the medium
8. Processing the resulting biomass to enhance its usefulness and its storage capacity (Srividya *et al*., 2014).

Steps the Process of Producing Single Cell Protein

Single cell protein production process takes the following steps:

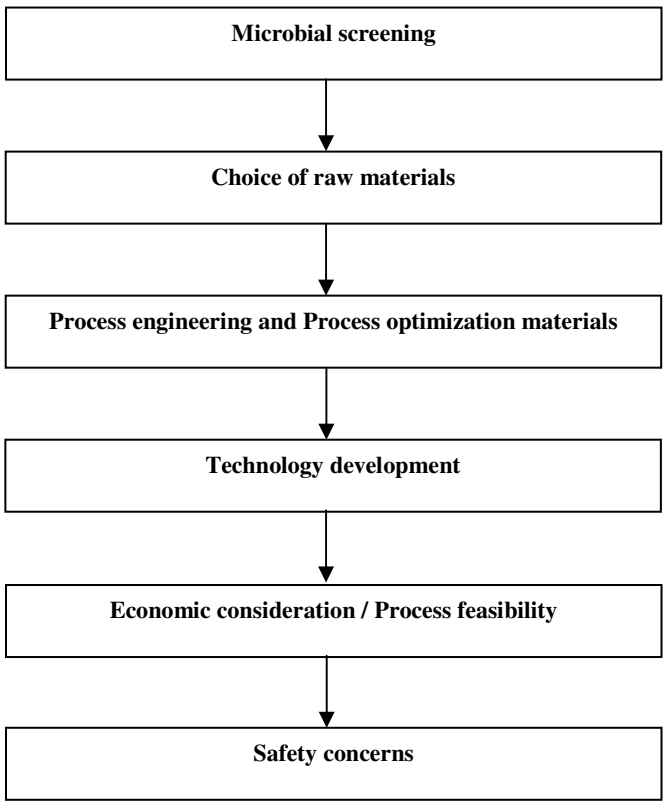

Fig. 1: Scheme Showing Steps for Producing Single Cell Protein (Wijeyaratne and Jayathilake, 2000)

Microbial Screening

The first step in the production process elects the appropriate microorganisms that produce a good amount of protein. The strains are collected from different sources such as water, air or soil, among others.

Microorganisms are selected by different studies containing mutagenesis and other genetic methods, sometimes wild types can also be used (Kuhad *et al*., 1997).

Choice of Raw Materials

Materials containing carbon, nitrogen, and phosphorus that contribute to increasing biomass production should be chosen within a short period of time, and mono- and disaccharides are desirable sources of microorganism's ability to benefit from them (Nigam, 2000).

Process Engineering

The highly efficient strains were elected in production by studying their metabolic properties and determining their cellular structures.

Technology Development

The adoption of advanced technologies in the production process to obtain a ready-to-use product on a large scale (Srividya *et al*., 2014).

Economic Factors / Process Feasibility

Low energy consumption and low production cost are among the most important factors of production and this requires careful and broad study.

Safety concerns

The safety of the product must be tested in terms of health, the most important of which is free of germs and their toxins.

Cultivation Methods

Single cell protein can be produced using three types of fermentation methods:

1. Submerged Fermentation
2. Semisolid Fermentation
3. Solid State Fermentation

Submerged Fermentation

The substrate used for fermentation which contains nutrients necessary for the growth of microorganisms, is always in the liquid state. The biomass is obtained by various techniques. The product is filtered by filtering or using centrifugation. heat generated during cultivation removed by using the cooling device (Kargi *et al.,* 2005).

Semisolid Fermentation

In semi-solid fermentation, the substrate usually used is in a solid state such as cassava waste. There are many processes required by the cultivation process, including stirring and mixing in a multi-phase system, transfer of oxygen in the form of gas bubbles through the liquid phase to the microorganisms, transfer of heat from the liquid phase (Adedayo *et al*., 2011). The fermenter adopted U-loop fermenter to determine the mass and transfer Energy (Oscar *et al*., 2010) gaseous hydrocarbons, methanol, ethanol, and n-alkenes can be used as carbon sources in addition to renewable sources such as polysaccharides, carbon oxide molasses, effluents of breweries etc (Talebnia, 2008).

Solid State Fermentation

Many studies have described different types of biomarkers, production process conditions and microorganisms used. In this process, the culture substrate, such as wheat bran and rice, is placed with the micro-organism, and this substrate is left for several days at room temperature (Singhania *et al*., 2009).

Disadvantages of Single Cell Protein

Despite the many advantages that a single cell protein has, there are some disadvantages that cause problems for a single cell protein, including:

1. Production of some toxic compounds that have a serious impact on animal and human health.
2. Diet supplements sometimes cause an allergic reaction.
3. The large amount of nucleic acids produced along with protein can cause digestive problems.
4. The protein production process requires high standard sterilization conditions (Bankra *et al*., 2009).

Applications of Single Cell Protein Production Technology

1. It contains high protein and low fat.
2. It can be produced throughout year.
3. The high protein content, which constitutes 85% of the dry weight of the biomass.
4. Cleaning the environment from waste such as wood waste, food processing waste, hydrocarbons, etc. which are used as a source of carbon.
5. A good source of vitamins and organic acids.
6. You do not need a laboratory for microorganisms (Suman, 2015).

Factors affecting the production of single cell protein

1. Carbon Sources

The most commonly used materials to produce single-cell protein are orange peels, sweet oranges, sugar cane, wheat straw, rice husk, sawdust, corn cobs, grape waste, coconut waste, mango waste, sugar cane pulp, etc. As well as traditional materials such as date molasses, fruit and vegetable residues, and non-traditional materials such as natural petroleum products (Suman *et al*., 2009; Uçkun Kıran *at el*., 2015). Lignocellulosic biomass such as hemicellulose and cellulose are a suitable substrate for good production (Suman *et al*.; Spalvins *at el*., 2018). The use of the correct substrate is one of the most important factors for its direct effect on the production process. Organisms interact differently with each substrate, so the rate of consumption of nutrients varies according to the substrate used. Table (2) shows the substrates that yeasts use as carbon sources.

Table 2: Yeasts and substrate used for as carbon sources (Fatemeh *et al*., 2019)

Substrate	Yeasts
Lactose	*Amoco*
n- Alkane	*Candida*
Methanol	*Saccharomyces*
Ethanol	
Hemicellulose	*Tricoderma*
Cellulose	*Kluyveromyces*
Maltose	*Thermomyces*
Pentose	*Rhodotorala*

2. Nitrogen Sources

The most important sources of nitrogen that are involved in protein synthesis are urea, nitrates, ammonia, ammonium salts and organic nitrogen. The yield of protein production varies according to the nitrogen source used. In study Haddish (Haddish, 2015) it was found that ammonium sulfate was better than ammonium nitrate as a nitrogen source for the growth of *C. utilis*. It was observed that the percentage of protein produced using *S. cerevisiae* was reduced by using organic nitrogen sources compared with inorganic sources. And when using *Candida* spp. to ammonium sulfate as a nitrogen source, it gave a high production of protein (Adoki, 2008). Zheng (Zheng, 2005) concluded in his study that the addition of C: N in a ratio of 1: 6 and 1 8: to the growth medium of *Candida* spp. and *Rhodotorula* sp. it increased the amount of protein produced.

3. Temperature and pH

Temperature is one of the most important factors affecting the growth of yeasts and thus affecting the production of monocyte protein. The optimum temperature for yeast growth ranges between 33 -35°C (Ghaly *et al*., 2005; and Zhao *et al*., 2010). It was found that 30 °C is suitable for the growth of *S. cerevisiae* and the production of single cell protein, while 25°C was the optimum for the growth of *C. utilis* (Akanni *et al*., 2014).

Several studies have used a pH between 3.5-7 to produce a singlecell protein using *S. cerevisiae* and 3-6.2 with *Candida sp.* (Schultz *et al*., 2006).

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