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Research Paper

Single cell protein: A probable tool to fight against food scarcity

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Abstract: Food scarcity is a global problem and is increasing day by day due to population explosion, rapid industrialization, increasing demand of natural resources and pollution. The scientists are trying to solve this problem by increasing agriculture productivity as well as harvesting animal resources. Now, this is also reached to a level of saturation so new tools and technology are needed to be explored to solve food problem. In the present paper, SCP production from different sources using many micro-organisms specially oil seeds cakes and Soya waste, as a substrate for single cell culture and protein production in laboratory and as a pilot project has been discussed in the present paper.

Keywords: Single cell protein, Food scarcity, Protein supplement, Yeast.

Abbreviation: single cell protein (SCP)

INTRODUCTION

The food supply in arithmetic ratio but the population of animals' increases in geometric ratio was very well stated by Thomas Robert Malthus, in the principles of population. The scarcity of protein-rich food and the existence of millions of poor people around the world have forced mankind to search for alternative protein sources that can replace conventional but expensive, soy meal of fishmeal. Hence, the focus has shifted towards relatively cheaper sources such as single cell protein (SCP) (Anupama and Ravindra, 2000). SCP are mixed proteins extracted from pure or mixed cultures of algae, yeasts, fungi, and bacteria, etc. which are grown on agricultural wastes SCP are used as a substitute for protein-rich foods, in human and animal feeds. In most parts of the world, natural pastures are the most important agricultural resources that provide the cheapest source of animal feed (Aucamp and Danckwerts, 1989).
However, theses are threatened by population explosion, overgrazing, poisonous plants, poor grazing management practices and human activities such as agriculture, housing and industrialization. All these place a demand on the already overburdened natural grazing resources (Malherbe and Cloete, 2002). The production of fodder in the semi-arid region is restricted by the

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irregular distribution of rain, resulting in low availability of livestock feed during the drought season. This results in the periodic use of commercial protein sources as supplements in feeds. Due the recurrent price rise of the commercial protein supplements used in feeding the animals, supplementation is becoming a non-economical activity for the breeders (Araujo *et al*., 2005). Therefore, the substitution of single cell protein (SCP) for the commercial protein supplements, namely the fishmeal and soybean meal, has attracted considerable interest in the dairy and poultry industries (Chanda and Chakrabrati, 1996; Rajoka, 2005).

The most common examples of food grade SCP are yeasts destined for use as food starters, yeast extract production, and as food and feed supplementation (Bekatorou *et al*. 2006). However, SCP production or development of other fermentation processes employing mixed food waste substrates, without addition of synthetic nutrients, has been scarcely reported (Aggelopoulos *et al*. 2013). To explore this possibility, the use of mixed cultures of species with different carbohydrate bioconversion abilities, such as kefir, has been proposed (Harta *et al*. 2004). Kefir is a natural dairy culture consisting of a symbiotic consortium of yeasts and bacteria, used for alcoholic and lactic acid fermentation of milk in the areas around the Caucasus (Plessas *et al*, 2011). Single cultures have also been used for waste utilisation, such as *Saccharomyces cerevisiae*, which is produced world wide mainly using molasses. Molasses is also a renewable carbohydrate-rich substrate, ready-to-use for ethanol productions (Kopsahelis *et al*. 2007). Its use for microbial growth is determined by its availability and cost, composition and absence of toxic substances and fermentation inhibitors (Bekatorou *et al*. 2006).

Oil seeds cakes and Soya waste has been extensively studied as a substrate for single cell culture and protein production in laboratory has been discussed in the present paper.

DEFINITION OF SINGLE CELL PROTEIN

The term Single Cell Protein was coined by term Carol L. Wilson in 1996 (Gour et al, 2015). The protein obtained from microbial source is designated as *Single Cell Protein* (SCP). It is the dried cells of micro-organism which are used as protein supplement in both animal and human food. Besides high protein content (about 60-82% of dry cell weight), SCP also contains fats, carbohydrates, nucleic acids, vitamins and minerals.

MICROORGANISMS FOR SINGLE CELL PROTEIN PRODUCTION

Various bacteria, mold, yeast and algae have been employed for the production of single cell proteins. The bacteria include *Brevibacterium, Methylophilus methylitropous , Acromobacter delvaevate , Acinetobacter calcoacenticus,s Aeromonas hydrophilla, Bacillus megaterium, Bacillus subtilis , Lactobacillus species, Cellulomonas species, Methylomonas methylotrophus, Pseudomonas fluorescens, Rhodopseudomonas capsulata, Flavobacterium species Thermomonospora fusca.*

Some of the algae used are *Chlorella pyrenoidosa, Chlorella sorokiana, Chondrus crispus, Scenedesmus acutus, Porphyrium sp and Sprulina maxima.*

The filamentous fungi that have been used include *Chaetomium celluloliticum , Fusarium graminearum , Aspergillus fumigates, A. niger, A. oryzae, Cephalosporium cichhorniae, Penicillum cyclopium, Rhicopus chinesis, Scytalidum aciduphlium , Tricoderma viridae, and Tricoderma alba Paecilomyces varioti*.

Yeasts such as *Candida utilis* (Torula yeast), *Candida lipolytica*, *Candida*

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tropicalis Candida novellas, Candida intermedia and Saccharomyces cerevisiae are all among the various organisms that have been used for the production of SCP (Bhalla *et al*., 2007).

SINGLE CELL PROTEIN AS DIETARY SUPPLEMENT FOR HUMAN AND ANIMAL NUTRITION

Food products containing micro-organisms have been include in human diets, either deliberately or accidentally, for thousands of years, although the consumption of microbial biomass is not widely accepted by some people. Microbial biomass is responsible for the production of food products such as alcoholic beverages, cheese, bread, yogurt and Soya sauce (Tuse, 1984). Humans have enjoyed the delightful taste of basidiomycete fungi (mushrooms) and a few ascomycetes (Yeasts) for thousand of years. The term single cell protein was first introduced in 1968 at a meeting held at the Massachusetts Institute of Technology (MIT) to give a better image than "microbial protein" and "petroprotein" which were the terms originally used (Anupama and Ravindra, 2000; Mateles *et al*., 1967). The first purposeful SCP production originated in Germany during World War I, with the cultivation of baker's yeast, *Saccharomyces cerevisiae*, on molasses and ammonium salts to serve as a protein supplement to replace as much as 60% of the foodstuff Germany had been importing prior to the war (Boze et al., 1992; Giec and Skupin, 1988; Litchfield, 1983). Later during World War II, *Candida utilis* was cultivated on diverse waste products from the paper industry to serve as a protein source for both humans and animals (Litchfield, 1979). After to an investigation of the potential of micro fungi as flavour additives to replace mushrooms. In the 1950s some oil industries became interested in the growth of micro-organisms on alkanes as a feedstock for SCP production for feed and food (Litchfield, 1980).

NUTRITIONAL BENEFITS OF SINGLE CELL PROTEIN

SCP from yeast and fungi has up to 50-55% protein and it as high protein-carbohydrate ratio than forages. It is rich in lysine but poor in methionine and cystine. It has also been noted for having good balance of amino acids and rich in B-complex vitamins and more suitable as poultry feed. Waste materials are used as substrate for the production of these proteins have proteins with required amino acids that can be easily selected by genetic engineering and finally during the production of SCP biomass, some organisms produce useful bye products such as organic acids and fats. Mainly SCP is used for foods supplement, vitamin carrier and flavours carrier. SCP is also used in variety of food items like in soups, in diet recipes and in ready to serve meals.

MEDICINAL USE OF SCP

SCP is used in various medicines because they have mainly benefits such as increase antiviral activity, strengtheners and improve immune system, exhibit anticancer activity and building blood cells. Therefore, SCP is used in food stuffs so that they give double benefits.

BENEFITS OF PRODUCTION

Micro-organisms grow at a very rapid rate under optimal culture conditions.

The quality and quantity of protein content in micro-organisms is better compared to higher plants and animals.

The culture conditions and the fermentation processes are very simple.

Micro-organisms can be easily handled, and subjected to genetic manipulation.

A wide range of raw materials, which are otherwise wasted, can be fruitfully used for SCP production.

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Table: A selected list of micro-organisms and substrates used for single cell protein production.

S.No.	MICROORGANISM	SUBSTRATE
1	**Bacteria**	
	Methylophilus methylotrophus	Methane, methanol
	Methylomonas sp	Methanol
	Pseudomonas sp	Alkanes
	Brevibacterium sp	C_1-C_4 hydrocarbons
2	**Yeasts**	
	Saccharomycopsis lipolytica	Alkanes
	(previous name-Candida lipolytica)	
	Candida utilis	Sulfite liquor
	Kluyveromyces fragilis	Whey
	Saccharomyces cerevisiae	Molasses
	(baker's yeast)	
	Lactobacilius bulgarivcus	
	Tosulopsis sp	
3	**Fungi**	
	Chaetomium cellulolyticum	Cellulosic wastes
	Paecilomyces varioti	Sulfite liquor
	Aspergilus niger	Molasses
	Trichoderma viride	Straw, starch
4	**Actinomycetes**	
	Nocardia sp	
	Thermomonospora fusca	Alkanes
5	**Mushrooms (a type of fungi)**	Cellulose
	Agaricus biosporus	
	Morchella crassipes	Compost, rice straw
	Auricularia sp	Whey, sulfite liquor
	Lentinus edodes	Saw dust, rice bran
	Volvariella volvaceae	Saw dust, rice bran
6	**Algae**	Cotton, straw
	Spirulina maxima	
	Chlorella pyrenoidosa	Carbon dioxide
	Scenedesmus actutus	Carbon dioxide
		Carbon dioxide

Conclusion: Concluding, we can say that micro-organisms specially bacteria and yeast are very useful from fruit supplement production and waste management points of view the protein SCP produce by this method is rich in protein composition as well as easy to handle. Thus single cell protein production is a very important tool for fight against food scarcity.

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