

# Single Cell Proteins production from effluents of candies production

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Keywords: Single Cell Proteins; Protein production; process optimization; *Saccharomyces cerevisiae*

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It has been estimated that worldwide human population increased up to 250% in last six decades, passing from 2.6 to 7 billion persons. Moreover, this increasing trend will continue to the same rate in the next decades, bringing the population to 9 billion within the 2040. The 80% of the population will live in the urban areas or along the costs, making this zone particularly exploited from the environmental point of view. In fact, some of the main controversial aspects of this rapid growth are the depletion of natural resources and the need for sustainable food and feed supply. Currently, human nutrition depends essentially on agriculture, animal husbandry or fisheries but the growth of world population will require the research of new food sources. The growth in demand for livestock products suggests that there will be a consequent rise in demand for animal feed, not only of cereals but of other feeds and particularly proteins. The requirement of protein passed from 50 millions tons in the 1970s to over the 250 million tons in 2020, making the research of new protein sources for human and animal nutrition an urgent issue (Speedy, 2020).

At the moment, two ways are possible: the farming of edible insects as protein supply, or protein synthesis from microorganisms. Compared to edible insects, which grow on noble biomasses like crops, SCP can be produced on residual organic streams originated from food processing and present greater yields (FAO, 2013). Microorganisms are emerging tools for production of quality food resources. In particular, the protein obtained from microorganisms, has been defined as ‘Single Cell Protein’ (SCP). They consist in mixed protein extracted from pure and mixed culture of bacteria, fungi, algae, and yeast. SCP is a term which means that microbial cells are grown and harvested to accomplish the food requirement of animals or human due to its high protein content (Upadhyaya et al., 2016).

The choice of microorganism depends on numerous criteria such as, the growth of microorganism should be fast, and a broader range of materials may be considered as suitable substrates. Organisms to be cultured must have the following properties which are: i) Should be nonpathogenic to plants, human and animals; ii) Usable as food and feed; iii) Should have good nutritional values; iv) Not contain toxic compounds and v) Production cost should be near to the ground. SCP can be produced by two types of fermentation processes, namely submerged fermentation and semisolid state fermentation (Ageitos et al., 2011). In the submerged fermentation, the substrate to be fermented is always in a liquid phase with the nutrients required for growth of microorganism. The substrate is fed continuously and the same is for cells harvesting. The product is filtered or centrifuged and dried for the production of single cell proteins.

This research work investigates the performance of SCP synthesis from the liquid effluent of candies production. The effluent of the candy industry is rich in soluble sugars, resulting ideal for *Saccharomyces cerevisiae* growth. *S. cerevisiae* has fermentative capabilities and can utilize sucrose, glucose, fructose, and maltose as carbon sources and produce alcohol under anaerobic conditions. On the other hand, in aerobic conditions the growth and reproduction of yeast cells seem to be favored (Hezarjaribi et al., 2016). SCP production yield is strongly influenced by several factors. First of all, nutrients requirement is very important for the growth of *Saccharomyces cerevisiae*. Candies production’s effluent (CPE) is characterized by very low concentrations of nitrogen and phosphorous, known to be essential for the metabolism of microorganisms (Table 1). For this reason, the liquid fraction of agricultural digestate, derived from the anaerobic digestion of animal manure and rice straw, was mixed to CPE as nitrogen and phosphorus supplements and obtain a balanced feeding.

Table 1. Chemical characterization of CEP and agricultural digestate

	sCOD (g/L)	TKN (g/L)	TP (g/L)	TS (%w/w)	TVS/TS (%)
Liquid agricultural digestate	20.78 ± 0.2	7.19 ± 1.19	2.16 ± 0.3	6,29 ± 0,04	95,5 ± 1,62
CPE	80.99 ± 6.0	0.44 ± 0.04	0.05 ± 0.01	6.85 ± 0.01	97.12 ± 0.34

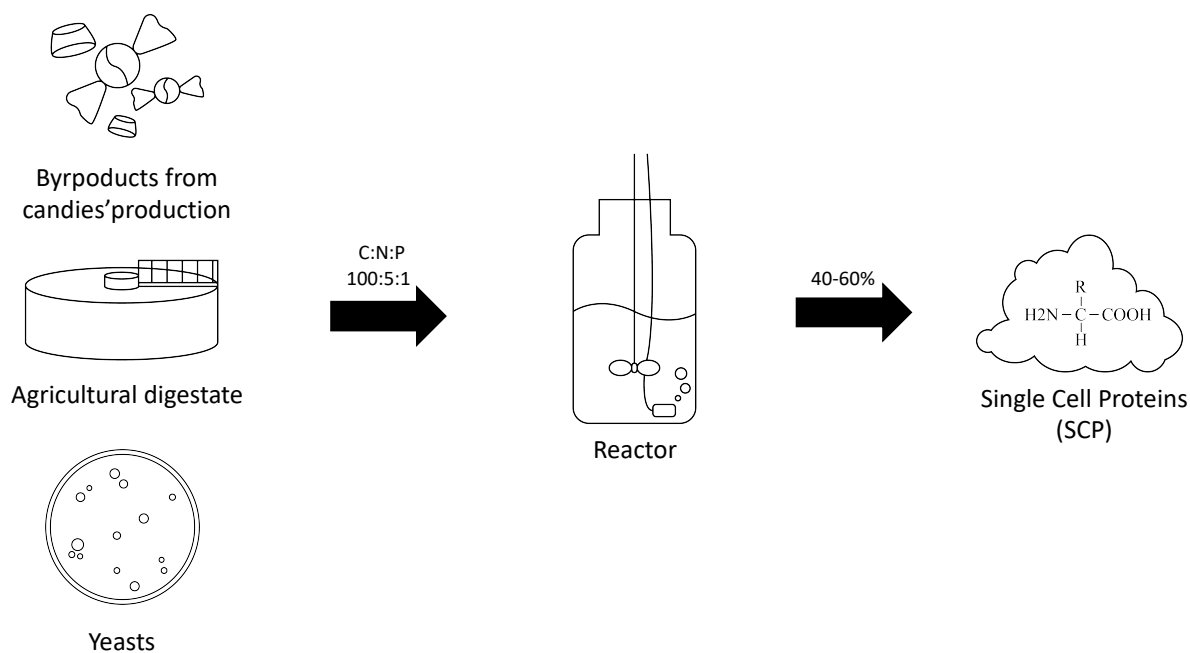


Figure 1. Graphical abstract of the process

CEP and liquid agricultural digestate were centrifugated to remove the bigger particles and thermally treated at 120°C to reach sterile condition. Then they were mixed to obtain the optimal C:N:P ratio of 100:5:1 (Figure 1). A commercial *Saccharomyces cerevisiae* (1% of the TS) was chosen for the SCP in 1 L liter reactor. Preliminary batch tests were conducted in anaerobic and aerobic conditions. It was observed that aeration allows for better performances in terms of nitrogen assimilation and, consequently, proteins accumulation. Anaerobic and aerobic tests achieved a biomass concentration of 5.03 and 8.72 g/L, respectively with a protein concentration around 25-30%. The better behavior of aerobic conditions was also confirmed by batch tests which led to similar results.

In the next experimental steps, the SCP production will be optimized for the continuous operation, investigating on the effects of different Hydraulic Retention Times (HRT) and the Organic Load Rates (OLR). The process will be evaluated considering the biomass growth rate, the kinetic degradation of COD and the N accumulation in the biomass. The aminoacidic profile of the proteins accumulated in the biomass will be also analyzed.

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