Production of single cell protein from different food waste

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Abstract - *Proteins are one of the most important nutrients required for both human as well as animal health. There is a need to find new solutions to suffice the world population's demand for protein consumption which cannot be obtained just by consuming plant-based protein or animal-based protein. Hence, the best alternative would be to switch to Single Cell Protein (SCP) which would also serve to improve the world's food security and scarcity. The food wastes have the potential to be used by microorganisms as substrate during fermentation processes to produce single cell protein. This review focuses on the utilization of several food wastes as a substrate through the process of batch fermentation to produce single cell protein using Saccharomyces cerevisiae as the source of microorganism. Comparative analysis of application of orange peel, banana peel, apple peel, pineapple peel and fish waste as substrate to produce single cell protein has shown that they all can be used together without the need for segregation. The product obtained yielded a good protein content and hence, could be used as a potential protein substitute for animal feed. More sustainable and economical methods of producing single cell protein are being discovered by researchers all over the world. Hence, the application of single cell protein for both human as well as animal feed could be a great alternative solution to protein sources through simultaneous bio-valorization of food waste.*

***Key Words*: Proteins, Single Cell Protein, Animal feed, Fermentation, Food wastes, Bio-valorization**

1. INTRODUCTION

One of the basic macronutrients that are extremely important for the structural and functional component of life is protein. The United Nations Food and Agricultural Organization (FAO) refers to proteins as macromolecules. They are essential for the function of cells, tissue, muscles, and organs. A protein's amino acid composition determines how nutrient-dense it is. Only by consuming a range of protein sources can one obtain the bulk of the essential amino acids. The consumption of several nutrients found in food is necessary for adequate human nutrition. The necessary amino acids are found in proteins, which are important macronutrients. The nutritional quality of a protein supply might vary depending on its amino acid composition, bioavailability and individual body requirements[1]. Although there are many sources of proteins available for human consumption there has been a need to investigate the food security and environmental issues with increase in the availability of various available sources of protein. Legislations related to novel food or genetic modification need to investigate the relevant regulatory framework to ensure the safety of alternative proteins. Lastly, additional studies on the food safety aspects of alternative proteins are urgently needed for providing relevant food governing authorities with sufficient data to oversee that the technological progress in this area is balanced with robust safety standards[2].

1.1 Single Cell Protein

In order to meet the need for animal-derived protein at present consumption rates and feed the world's population, it has been estimated that the globe must produce at least 1,250 million tons of meat and dairy annually by 2050. Consequently, a major issue in a society with a continuously growing population is the consumption of proteins that are both affordable and readily available while also satisfying environmental and social concerns[3].Therefore, food security will be a matter of global concern that is tough to address with existing methods of agriculture and constrained by the depletion of natural resources and climate change. To enhance the effectiveness of the food production system and to decrease the negative externalities of agriculture, novel technologies are urgently needed. Hence, the production of microbial protein in extremely controlled, intensive systems known as bioreactors is one of the most cutting-edge technologies to which, both science and business are developing attention[4].

Unicellular edible microorganisms are referred to as Single Cell Proteins (SCP) or microbial proteins which are characterized as biomass or protein extract from pure or mixed cultures of algae, yeasts, fungus, or bacteria. It can be used as additives or substitute for protein-rich meals and is safe for human consumption as well as animal feed. Protein has vital roles in maintaining life through its control of biological processes and use in bodybuilding. Humans as well as animals need an adequate quantity of protein, which cannot be obtained solely through conventional sources. This is a result of the world population's fast growth. Researchers are investigating the creation of Single Cell Protein (SCP), a different protein source, using wastes and low-value materials which, can provide both people and animals with high-quality protein containing both essential and non-essential amino acids[5], [6].

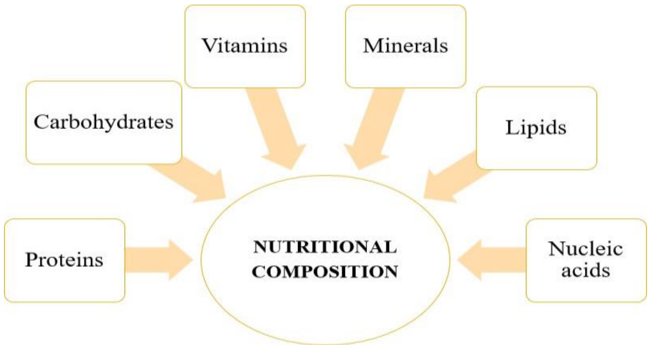

Fig -1: Nutritional composition of single cell protein

The very first product of the fermentation process was the production of Single Cell Protein (SCP), which has proven to be a useful protein substitute. As the world's population continues to increase, food competition is getting more intense. SCP might soon be able to make up for a lack of protein. Numerous global businesses are concentrating on SCP manufacturing and as their expertise and time advance, so does the extent of its use[7]. SCP offers several advantages over animal and plant proteins since it can be generated all year round and does not depend on the seasons or climate for growth. It does not require a lot of land, has a high protein content with a wide range of amino acids, is lower in fat, and has a greater protein-to-carbohydrate ratio than forages[8].

1.2 Bio-valorization of food wastes

Bio-valorization refers to the process of reducing, reusing, and recycling food waste into useful products also referred to as value added products. Food waste is a significant portion of municipal solid waste and comprises food waste from houses, markets, restaurants, processing companies and additionally, several agro-industrial operations also generate cheap wastes from all over the world.

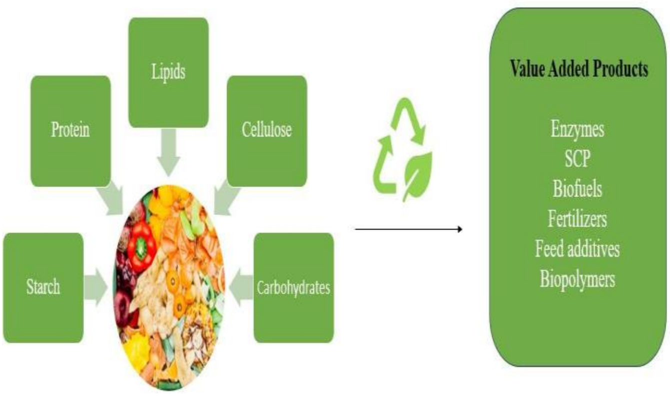

Fig -2: Production of value-added products from food waste

The amount of food waste is quite large everywhere due to the rapid economic development and continuous population expansion and it has been predicted that by 2025, the production of food waste worldwide would exceed 2.5 billion with an annual rate of 40%. In fact, the majority of wastes continue to be disposed of improperly and without being utilized, which makes the problem worse[9], [10].A major obstacle to effective waste management are the challenges associated with the right collection methods, storage and bioconversion of food waste into valuable added products[11].Finding ways to use waste for the environment's benefit has recently become a top priority. To address this issue, the scientific communities have been using wastes and effluents through recycling and clean technology through integrated waste application else have simply been returned to their natural source[12].As an alternative to petroleum-based chemicals, biorefineries create commodity and specialty chemicals as part of a circular bioeconomy. A potential strategy for producing value-added products in a sustainable manner involves using waste streams including food waste and agricultural waste as a feedstock for biorefineries[13]. There is a lot of waste produced by the seafood sector. These comprise low-value underutilized fish that are taken as by-catch in commercial fishing operations, as well as large volumes of wastewater released as effluents. Processing discards also include fish that have been stripped of their fins and shells[14].Proteins, amino acids, lipids with healthy amounts of polyunsaturated fatty acids, carotenoids and minerals are abundant in the discards, effluents, and by-catch. Sustainable seafood production may be supported by eco-friendly and cost-effective handling of seafood waste using bioconversion alternatives and a bio-refinery strategy[15].Hence, biorefineries are the major contribution in terms of bio-valorization of food waste to produce value added products[16].

Every component of the food supply system experiences food losses which, ends up as waste. These waste materials are disposed in landfills, where toxic substances that are discharged into the air, water, and soil cause adverse environmental effects. Hence, the utilization of food waste in a range of value-added products and energy vectors has been the subject of several research projects. The microbiological upgrading of these wastes by fermentation has been shown to be a promising valorization option, making it one of the most important innovations in science[17], [18].Food wastes are abundant in nutrients and substances that are bioactive in nature. Such wastes have a variety of components, including proteins, minerals, and carbohydrates, therefore they ought to be seen as raw materials rather than waste products for other industrial operations. The presence of these nutrients in these wastes provides favorable circumstances for the rapid development of microbes. Hence, the waste has the potential to be used again by microorganisms as a source of food during fermentation processes to produce value-added products. This approach of wealth from waste contributes to waste recycling, which helps safeguard the environment[19].

2. PRODCUTION OF SINGLE CELL PROTEIN USING DIFFERENT FOOD WASTES AS SUBSTRATE

The recovery or production of value-added products through the process of fermentation such as single-cell protein , biofuels, animal feeds, enzymes, feed additives, and various other bulk chemicals and products have recently become the focus of several initiatives to use waste biomass[20]. Biodegradable waste is treated microbiologically to guarantee that harmful compounds are neutralized in order to reduce environmental contamination. Additionally, the creation of value-added products from these wastes makes certain recycling initiatives more profitable. One product that may be produced from diverse waste sources by microbial fermentation is single-cell protein[21].There are several microbial species that might be used to produce the. Making single-cell protein using cheap materials as a substrate provides an economically sensible protein source for animal feeding or for human consumption, as this typically satisfy dietary demands for protein. Numerous microorganisms have been used to convert a wide range of substrates into single-cell proteins that are used to produce biomass rich in protein content[22].

In the year 2022, a study was conducted by A. Tropea et al., using *Saccharomyces cerevisiae* ATCC 36858 as the source of microorganism for the process of fermentation using a multicomplex substrate made up of five different food wastes. This would make it possible to simultaneously bio-valorize a variety of food wastes without having to separate the waste from the food process to get a feed-worthy single cell protein. In light of the waste's chemical composition, cellulolytic enzymes were added to the medium to simultaneously saccharify and ferment in order to obtain free sugars from the cell wall of agricultural food waste that would be suitable for yeast growth[23]. Although, in many studies the similar procedures have been followed for the production of SCP using the substrates individually like orange peel substrate[24]; banana peel substrate[25]; fish waste[26]; pineapple waste[27] by using different micro-organism strain and different optimization conditions.

The following procedure (Fig -3) was followed for production of single cell protein using different food wastes at a lab scale level according to A. Tropea et al.,

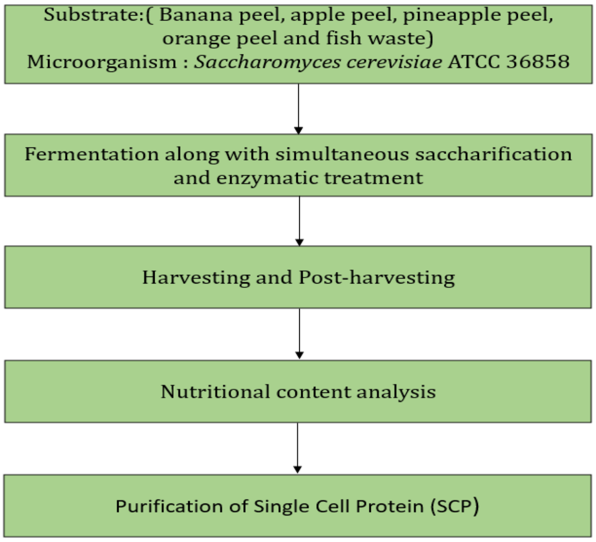

Fig -3: Production of single cell protein from food waste through the process of fermentation

2.1 Comparison of crude protein and crude lipid content in different food waste substrate

As mentioned in the previous section, many studies have been conducted on application of food wastes such as banana peels, pineapple peels, fish waste and orange peels which have been done successfully but, they have been used individually as a substrate for the process of fermentation to produce single cell protein. Although the highest protein content was obtained by using fish waste as a substrate, from (Table-1) it is evident that the protein content was high even in application of multiple food wastes as substrate through the process of fermentation.

Table-1: Comparative Analysis

SUBSTRATE	MICROORGANISM	PROTEIN CONTENT (%)	LIPID CONTENT (%)
Multi food waste	*Saccharomyces cerevisiae*	40.19 ± 2.13	14.59 ± 0.83
Orange peels	*Saccharomyces cerevisiae*	1.06	9.11
Fish waste	*Saccharomyces cerevisiae* (ATCC) 4126 and *Lactobacillus reuteri* ATCC 53608	48.52 ± 1.51	15.25 ± 0.81
Banana peels	Torula yeast (*Cyberlindnera sp.*)	9.04	6.08
Pineapple peels	*Saccharomyces cerevisiae*	7.43	5.04

Hence, it can be concluded from (Table -1) that more protein content could be obtained when multi food waste is used as a substrate which, allows for simultaneous bio-valorization as well as the production of value-added product which is single cell protein.

3. CONCLUSIONS

This study showed a powerful way to deal with utilizing a multicomplex substrate, made up of various food waste which led to set up a lab-scale maturation process permitting the execution of a concurrent valorization of various food waste, without the need to isolate the waste emerging from the food process for getting an additional worthy item. Specifically, this study directed the chance towards utilizing both fish and fruit waste together, by a concurrent saccharification and fermentation process for getting single cell protein using *S. cerevisiae,* which may be appropriate as animal feed. The final fermented product obtained at the end of the process of fermentation can be used as an animal feed in the form pellets or powder which, is enriched with the right amount of nutrients that is essential for the animal diet. Hence, this serves as a great supplement which, could be used as an animal feed for the following purposes:

- Fattening and stuffing of hens, pigs, cows, etc.
- To enhance the overall nutritional value of the animals through diet.
- As an alternative to aquafeed enriched with nutrients.

The current methodology followed is feasible at lab scale and is yet to be executed on a large scale in the industries which, will require a lot of optimizations. Although, the final product obtained has good number of nutritional values it cannot be recommended for human consumption due to the presence fish waste which, might be one of the major drawbacks. Businesses and researchers from all over the world are interested in single cell protein production because of the numerous promising benefits these products provide. However, finding a sustainable, renewable protein-enriched ingredient is a major obstacle for the sector. As more and more new technologies are coming up, it has become a top priority to come up with new solutions that could be beneficial to the environment as well as the living organisms. One such product would be production of single cell protein that would not only be an alternative protein source but, would also contribute to bio- valorization.

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