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Review Article

# Yeast Protein: Novel and Alternative Protein in Food Applications

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## Abstract

More than two decades ago, biological systems, including systems, were used 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, allowing them to benefit from cheap sources of carbon. The ability to produce proteins is crucial. Single-celled organisms are more affordable on a commercial level, and because they can be produced in large quantities and are dependent on agricultural and industrial waste, they are not affected by climatic changes or natural disasters. There is a demand for the development of novel and alternative proteinaceous food sources due to the growing population. Since antiquity, the use of microorganisms in the production of food has been investigated.

**Keywords:** single cell protein, proteins, food, waste

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## Introduction

The global population increases the demand for food, particularly protein products [1]. Animal protein consumption has been linked to an elevated probability of premature death from cardiovascular disease and type 2 diabetes [2]. Almost half of African countries' populations utilize less than 10 kilograms ’of meat per year. These countries are experiencing a protein supply shortage, which is becoming a public health concern [3]. However, protein shortages, such as those of meat, dairy, and plant protein, are a problem not only in underdeveloped nations in Africa, Asia, and South America, but they could also develop in the future in developed nations [4]. The creation of readily available protein products that have no adverse effects on human health is therefore one of the most urgent issues facing the world's expanding population. Additionally, people in developed nations are interested in producing healthier foods that are manufactured in an environmentally sustainable manner and have an appropriate amino acid composition as well as an acceptable amount and quality of fat. Obtaining single cell proteins from yeast cells derived through growth in waste products from numerous sectors of the agri-food industry may be extremely relevant in the case of conventional agriculture. Therefore, acquiring a well-balanced, sustainable high-protein from yeast cell biomass, which can be an excellent substitute for conventional protein supplements [5].

Yeast is a single-celled eukaryotic microorganism that belongs to the phylum Ascomycetes in the kingdom of fungi [6]. Yeasts are fungi with vegetative states that reproduce primarily through budding or fission, growing primarily as single cells in the vegetative phase. Ascomycetous and basidiomycetous yeasts are among them. Yeasts have numerous applications in the fermentation, food, feed, agricultural, biofuel, medical, and chemical industries, as well as environmental protection [7, 8]. Given that yeast cells have a nutritional profile that is similar to soy flour in terms of their percentage of protein, fat, and carbohydrates, they have the potential to become a more substantial part of a person's diet. 1.5% lipids, 34.6% carbohydrates, and 13 kJ per gram of dry cell weight. Histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine are all essential amino acids that humans cannot produce and must obtain from dietary sources. The amino acid profile of yeast proteins is also suitable for human nutrition [9]. Nutritional yeast biomass, such as single-cell protein (SCP), is widely used as a source of nutritional components [10, 11]. Yeast protein biomass can be used as a supplement to the main diet instead of more expensive sources such as soybeans and fish. Protein deficiency affects 25% of the world's population, according to the World Food and Agriculture Organisation (FAO) [12]. Despite its numerous advantages, nutritional yeast production has received little attention because yeast biomass is not widely accepted as a protein supplement for humans. As a result, efforts should be made to find methods that will lead to global acceptance of this valuable nutrient supplement. Thus, using yeast biomass as an alternative nutrient supplement can help to solve the problem of food scarcity for the world's rapidly growing population, particularly in developing countries [13].

## Production of Yeasts Single-cell Protein from Specific Waste Substrate

Yeasts, as living microorganisms, are not particularly demanding in terms of living conditions; thus, they are widely distributed in the natural environment. Every year, more yeasts are discovered; currently, only 1500 species are known. This represents 1% of their total population. It is estimated that the kingdom of fungi (Fungi) contains up to 150,000 organisms [15]. As seen in **Table 1**, a variety of hydrophilic and hydrophobic wastes and by-products, biomass, and raw materials are typical sources of yeast growth substrates for protein biomass production and also fatty substrates favour a high-protein concentration in yeast biomass [16, 17]. It is also simple to use domestic sewage, wastes from food processing, wastes and by-products from starch production, and other agricultural wastes [18]. It is best to select such waste substrates that are affordable or free and that are also simple to access. The production of yeast proteins uses these substrates, which helps to lessen pollution. In order to support the best growth of the chosen strains, it is occasionally necessary to add additional nutrients, such as nitrogen, phosphorus, and others, to a waste culture medium. Thereby, agricultural wastes are found to be excellent substrates for producing protein at a low cost, producing yeast protein biomass in good numbers and of high quality [19, 20].

**Table 1** Reports of yeast protein content produced from specific waste substrates by different yeast species [14]

| Yeast species | Waste substrate | Protein content |
|---|---|---|
| *Blastobotyrs adeninivorans (syn. Arxula)* | Spruce dived sugars and protein hydrolysates from chicken-by products | 50% |
| *Candida sp.* | Prawn-shell waste | 60-70% |
| *Candida arborea* | Rice straw hydrolysate | 58.5% |
| *Candida krusei* | Cheese whey | 48% |
| *Candida lipolytica* | Alkaline hydrolyses of olive fruit wastes | 59% |
| *Candida pararugosa* | Olive mill wastewater | 35.9% |
| *Candida tropicalis* | Sugarcane bagasse | 60% |
| *Saccharomyces cerevisiae* | Food waste, pineapple waste, papaya waste, cacao, jackfruit etc. | 30-50% |
| *Wickerhamomyces anomalus* | Spruce- derives sugars | 50% |
| *Zygosaccharomyces rouxii* | Spoiled date palm fruit | 49% |
| *Yarrowia lipolytica* | Rye and oat agricultural wastes, industrial wastes | 30-46% |

## Production of Yeast Proteins

SCP is obtained in much shorter duration and is cheaper to cultivate from various microorganisms. Moreover, yeast can be utilized for producing protein biomass from various agricultural waste acting as substrate for the cultivation of microorganism. Due to the characteristics of protein structure, nitrogen plays a significant role in protein synthesis. Ammonia, ammonium salts, urea, and organic nitrogen in a variety of media are nitrogen sources helpful for microbial growth. Industrial waste materials are an example of this [21]. Tryptone and yeast extract make for the best sources of nitrogen. The highest protein yield was obtained when tryptone was added at a concentration of 0.8% weight/volume [22]. It is important to note that Zheng *et al*., 2005 discovered that using salad oil as a growing medium, the N:C ratios of 1:6 and 1:8 produced SCP from *Candida* and *Rhodotorula* species. K2HPO4 and NaH2PO4 were the top two phosphorus sources out of 27 for the production of proteins. Yeast species can grow in both liquid medium and solid-state fermentation cultures. The yeast can then be further cultured in submerged fermentation, semisolid fermentation, or solid-state fermentation (SSF) [23]. The culture medium of choice affects the fermentation method of choice. However, solid fat materials, such as tallow, require considerable agitation to be dispersed in the culture medium, whereas liquid oil substrates for oleaginous yeast are easier to disperse with moderate agitation [24]. The rate of yeast cell growth is significantly influenced by the culture medium's composition [25]. Thus, the composition of the growth medium as well as culture conditions like incubation temperature, pH, or the moisture content of solid cultures, dissolved oxygen, and aeration content have a significant impact on the yield of protein and yeast biomass. Thus, the optimization of culture medium is done in a fermenter [26]. Particularly when biomass is being prepared for human nutrition, the medium should be sterilised to prevent contamination. The waste culture medium's components can be heated or sterilised using filtration. Additionally, fermentation equipment needs to be sterilised [27].

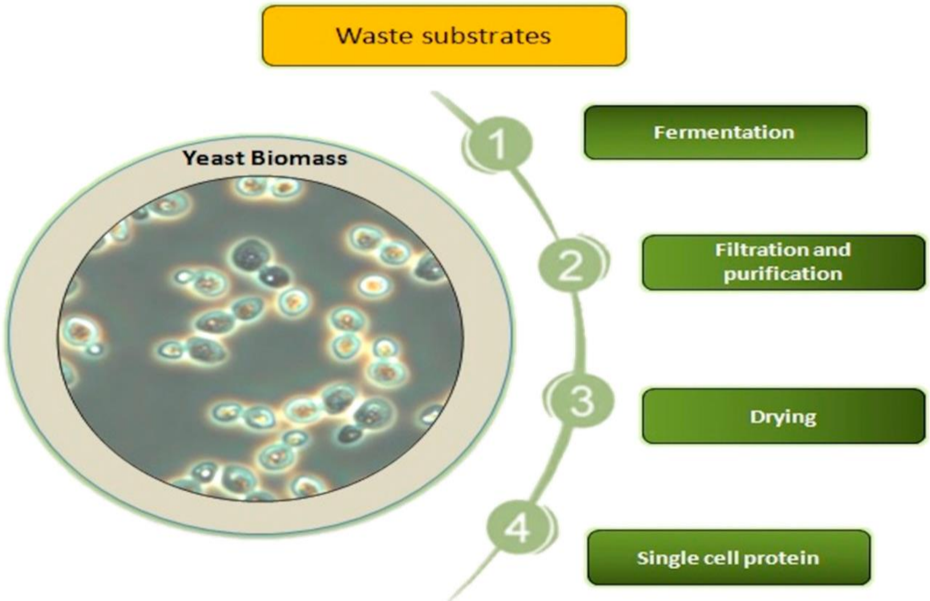


**Figure 1** Single-cell Protein Production by Yeast [14]

The total 70–80% of nitrogen in a cell comes from amino acids, with the remainder coming from nucleic acids, particularly RNA. Yeast protein biomass contains more nucleic acids than other conventional protein sources, which is a characteristic exhibited by all fast-cultured microorganisms [28]. The majority of microorganisms have 4–20% nucleic acid in their biomass [29]. However, most yeast only contain 5% to 8% of nucleic acids, which is better than bacteria, which have between 8 and 15%. For instance, biomass of *Candida tropicalis* grown on soy molasses contained 5.28% of RNA [30]. *Candida langeronii* developed on hydrolyzed bagasse hemicelluloses contained 5.8% of nucleic acid [31]. Food should be of appropriate health quality in addition to providing the necessary nutrients. Because alkali purines (adenine and guanine) are broken down into uric acid, which is harmful, single cell protein produced for human consumption needs to be nucleic acid-free. Before being utilised in feed and food, yeast protein should have all desirable functional properties. The cell wall of yeast should be destroyed to improve yeast SCP digestibility and bioavailability by drying at high temperatures or using mechanical forces such as crushing, crumbling, grinding, pressure homogenization, or ultra-sonification [32, 33, 34]. The moisture concentration of dried yeast biomass can be reduced to less than 6% using the drying method [35]. A moisture level of less than 8% in the powder is considered safe for a long shelf life of up to 2 years. Drying occurs before or after grinding and is critical in achieving proper texture and stability of yeast biomass as food ingredients [36].

## Different types of methods for cultivation of yeast (SCP)

Yeast (SCP) can be produced using three types of fermentation methods:

### *Submerged fermentation*

The fermentation substrate, which contains the nutrients needed for microorganism growth, is always in a liquid state. The biomass is obtained using a wide range of methods. Centrifugation or filtering are both used to purify the product. The cooling device is used to remove heat produced during cultivation [37].

### *Semi-solid fermentation*

The substrate used in semi-solid fermentation is typically in a solid state, like cassava waste. A multi-phase system must be stirred and mixed, oxygen must be transferred to the microorganisms in the liquid phase in the form of gas bubbles, and heat must be transferred from the liquid phase to the microorganisms [38].

### *Solid state fermentation*

In this procedure, the microorganism is placed with the culture substrate, such as wheat bran and rice, and this substrate is left for a few days at room temperature [39].

### Nutritional Properties of Yeasts Proteins

It is known that yeast biomass and yeast-based products are typically rich in proteins and several important compounds, such as vitamins and minerals and the amount of lysine, the most-scarce amino acid in wheat, the most prevalent amino acid in cereals, is comparable to the amount of amino acids in protein biomass among yeast species. The levels of isoleucine, leucine, lysine, phenylalanine, threonine, and valine in the yeast protein amino acids profile are higher than those recommended by the Food and Agricultural Organisation (FAO)/World Health Organisation (WHO) for the human diet [40, 41]. The average amount of protein in 100 grams of yeast biomass is 47 g, or exactly 100% of the adult daily protein recommendation of 50 g. According to FAO recommendations, yeast protein also contains all essential amino acids in the proper amounts, making it a complete source of a protein [42]. Additionally, yeast protein biomass is a good source of micronutrients like selenium and chromium as well as macro-elements like calcium, phosphorus, and zinc. These elements are present in the biomass in bioavailable organic forms [43]. Additionally, the biomass of yeast proteins contained significant amounts of vitamin B12 and other B-complex vitamins. The coenzymes involved in the metabolism of carbohydrates, lipids, and proteins include biotin, folic acid, pyridoxine, riboflavin, thiamine, and cyanocobalamin, all of which are found in yeast protein biomass. For the human body to function optimally in terms of neurological and physiological processes, an adequate vitamin concentration is necessary. It's important to note that people living in developed countries frequently consume diets deficient in B vitamins [44].

## Conclusion

Nutritional yeast biomass possesses a high protein content, a good balance of amino acids, including those that are essential, and little lipid content. Yeast protein is a cheap supplement that can be added to the typical human diet to help address the global protein and food shortage issue. Yeast biomass or extract is frequently used as a vitamin carrier, emulsifying stabiliser, and flavour enhancer in a variety of foods. A variety of agricultural, forestry, and industrial wastes can be converted into yeast protein, which aids in waste material recycling and the removal of pollutants. Thus, using alternative protein sources made from waste products from various industrial branches can help substantially solve important economic and environmental issues.

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