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Research on the application of microbial biomass in resource utilization of agricultural product processing waste

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Abstract. Microbial biomass can effectively treat waste from the agro-food industry. Urbanization and economic development have escalated, causing environmental degradation. With the development of the economy and the improvement of people's living standards, the total amount of waste today is huge, and there are many types. Waste management challenges far exceed those of the early 20th century, requiring innovative solutions and modern environmental protection technologies. Industrial waste is costly to recycle, while animal and plant-based organic waste like potato wastewater, whey, lignin, and cellulose dominate. This article explores the utilization of microorganisms for waste treatment. Yeast biomass offers a solution to reduce waste disposal costs and generate valuable metabolites such as β-glucans, vitamins, carotenoids, and enzymes with wide industrial applications. Discovering new applications for yeast, fungi, and bacteria can enhance their effective use in various biotechnological fields.

Keywords: Microbial biomass, utilization of microorganisms, recycle waste

1. Introduction

Advancements in technology and economic development have led to the depletion of natural resources, emphasizing the need to reuse and recycle waste. Yeasts, a type of microorganism, have the ability to biodegrade waste and offer environmental protection with minimal economic costs. Continuous research has led to the discovery of novel yeast strains that can transform raw materials into valuable products such as biomass, protein hydrolysates, and B vitamins. By applying modern molecular biology techniques, it is possible to enhance yeast cells and increase the production of these compounds. This approach plays a crucial role in effective waste management and the conservation of natural resources. Using biotechnologically modified strains can have potential negative consequences that need to be recognized. The uncertainty stems from the unpredictable outcomes linked to modified microorganisms. Another way to improve the economic viability of metabolite production using yeast is by utilizing low-cost waste-derived microbiological media. These media can provide suitable cultural conditions for the biosynthesis of specific metabolites.

Continuous research is driven by the desire for pro-ecological applications of yeast, with contamination on the rise due to excessive production of decomposable raw materials. If left untreated, unprocessed waste can facilitate the growth of pathogenic microorganisms, leading to environmental degradation and the spread of diseases. The examples presented in this article present opportunities for the development of innovative concepts in waste management through the use of microorganisms, which can potentially yield attractive products.

The article discusses various methods for waste disposal involving microorganisms. These microorganisms enable the conversion of byproducts from production into valuable raw materials. The utilization of yeast cells encompasses fermentation processes, as well as the biosynthesis of vitamins, enzymes, and bio surfactants, among other techniques.

2. Selected waste from the agro-food industry

2.1. Potato Biomass

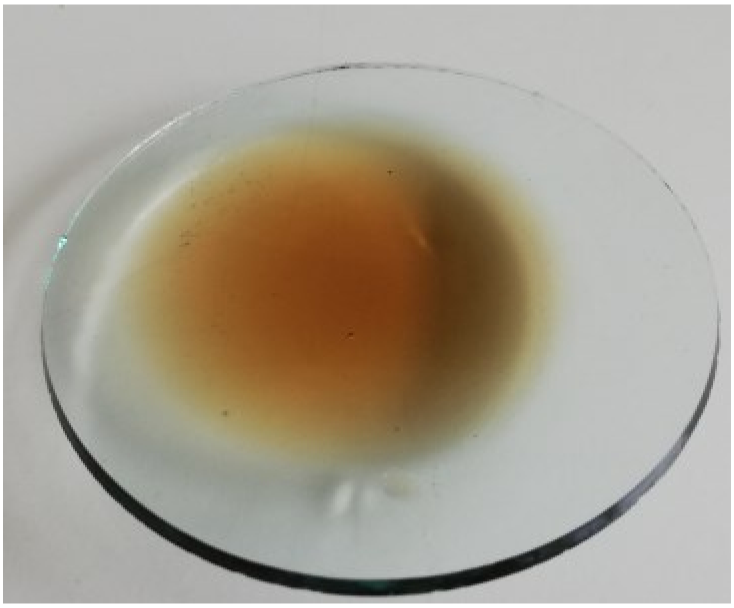

Figure 1. Potato wastewater

The whole food industry produces a substantial volume of waste liquid containing valuable biogenic elements and organic compounds. However, effectively utilizing this wastewater is challenging and costly. Waste produced during potato processing, particularly potato wastewater(Figure 1) from starch production, can serve as a nitrogen and mineral source for yeast. Approximately 600 m3 of potato wastewater is estimated to be generated when processing 1,000 Mg (megagrams) of potatoes [1]. European Union guidelines restrict the release of industrial wastewater, leading to the creation of novel waste utilization techniques. Liquid waste from the food sector, for example, can be converted to ethanol using genetically altered Escherichia coli strains. Furthermore, Rhizopus arrhizus molds can use potato wastewater for lactic acid biosynthesis, a common component in food and fermentation.

Nowak and his team reported that they cultivated Aspergillus niger NRRL 334 in deproteinized potato wastewater, yielding 13 g/L of biomass and a 58% drop in the COD index. Huang and his group showcased R arrhizus DAR 36017, with 10 mg of $CaCO_3$/L, generating 21 g of lactic acid per liter in 28 hours due to full starch breakdown. Liu et al. [4] formulated a single-cell protein (SCP) mix with Bacillus pumilus, Candida utilis, and A. niger at a 7:2:1 ratio, boasting about 46% crude protein. Muniraj et al. [5] used Aspergillus flavus and Mucor rouxii to derive fat and γ-linolenic acid. They also noted over a 50% reduction in BOD5, COD, phosphorus, and nitrogen levels in the medium.

Kieliszek et al. [6] found that potato wastewater can be used as a cultivation medium for C. utilis ATCC 9950 yeast. This yeast biomass is beneficial for creating vitamin-mineral supplements. Feed yeast offers essential vitamins, enzymes, proteins, and vital bioelements like selenium. Bzducha-Wróbel et al. [7,8] used potato wastewater for (1,3)/(1,6)-glucans synthesis. These polysaccharides, with antimutagenic, antioxidant properties and ability to lower blood cholesterol levels, are valuable in pharmaceuticals and other sectors. Thus, repurposing potato-processing waste for products like ethanol and lactic acid cuts costs and lessens environmental impact.

2.2. Apple pomace

Figure 2. Glycerol

Table 1. Chemical composition of apple pomace(%) [17]

Components	Kosmala et al.	Skinner et al.	Sato et al.	Magyar et al.
Dry matter	95.4	N.d.	88.57	N.d.
Protein	5.7	2.7-5.3	2.74	N.d.
Dietary	61.1	4.4-47.3	43.63	40.3
Carbohydrates	25.3	44.5-57.4	39.35	20.2
Pectin	N.d.	3.2-13.3	N.d.	N.d.
pH	N.d.	N.d.	N.d.	N.d.
Ash	1.1	N.d.	1.80	2.2

Fruit processing leads to considerable waste and wastewater accumulation. When apples undergo processing for juices or alcoholic beverages, a notable volume of peel, seeds, and pulp, termed apple pomace, emerges (Figure 2). This pomace represents about 20% to 30% of the apple's dry matter, contingent on its variety [9,10].

Apple pomace consists of elements like peel, core, seeds, calyx, stem, and soft tissue. About 75% of its content is water. It also includes carbohydrates such as cellulose, hemicellulose, and lignin. Additionally, it comprises sugars (making up 7%), an array of minerals, pectin, proteins, and vitamins [11-13,15]. Its chemical profile varies based on the raw material, maturity, pressing technique, and the number of pressings [14]. Given its nutrient-rich nature (Table 1), apple pomace is a promising resource for various product development [15,16].

Numerous studies delve into turning pomace into products like phenols, lactic acid, and ethanol. In the USA, the primary ethanol source is maize grain starch, categorized as a first-generation biofuel. Producing ethanol from grains, including corn and wheat, is debated due to potential food wastage. An alternative is using industrial residues like apple pomace to produce second-generation biofuels or other valuable compounds.

Globally, apple pomace presents an environmental dilemma because of its limited biodegradability. The USA annually produces about 1 million Mg of apple pomace from 2.6 million Mg of apples. Brazil generates around 800,000 Mg, mostly for animal feed, although its nutritional value is questionable. India yields close to 1 million Mg of apple pomace annually, but only 10,000 Mg is managed appropriately [26]. An estimation suggests a global production nearing 80 million Mg in 2013. Handling this waste poses environmental concerns. For example, apple pomace has a high COD of 250–300 g/kg

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and may spontaneously ferment. Landfill storage leads to economic and material losses, costing the USA over $10 million each year. Only specific fruit seeds, like those from cherries or apricots, are viable as plant waste. With its high moisture content, apple pomace deteriorates quickly, especially in humid conditions, making it prone to fast microbial contamination. Thus, managing this massive pomace output efficiently remains a challenge for global processors.

3. Biomass Applications and Current Use

Apple pomace, a byproduct from edible fruits, offers potential for transformation into beneficial products for both humans and animals. Given its large production scale and nutrient-rich nature, it's economically feasible. One application involves using pomace to produce metabolites via numerous industrially-relevant microorganisms. The industrial and scientific sectors have shifted focus towards harnessing natural resources instead of environmentally detrimental disposal of agroindustrial byproducts. By bioconverting such residues through microbial biomass, we can obtain compounds with elevated commercial worth. These instances highlight microorganisms' pivotal role in apple pomace processing.

4. Conclusion

Microorganisms present substantial potential for environmental conservation and specialized metabolic product generation. Given our present understanding, it's crucial to emphasize specific microbial activity across different settings for procuring Single Cell Protein (SCP). Global evidence of waste management provides a robust base for industrial manufacturing, which includes yeast for animal nutrition, microbial biomass, vitamins, and enzymes. Using microorganisms to handle waste, especially from the agro-food sector, boosts various environmental safeguards. Leveraging waste for microbial metabolite extraction reveals innovative industrial possibilities. It's crucial to recognize that no single method exists for managing all waste types using microbial biomass. Consequently, the choice of a waste management technique hinges on the waste's characteristics and the microorganisms involved. Numerous waste handling techniques are available, differing in outcomes, progress level, and environmental repercussions.

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