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From Food (Bread) waste to Bioethnol Producation

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Abstract – A handful of studies and rough estimations confirm that roughly 1.3 billion tons of food get wasted. The staggering volume of food waste management has been shed light and constitutes a significant challenge because of -its environmental, social, and economic impacts. Recent estimates suggest that 8-10% of global greenhouse gas emissions are due to non-food conception, and the global economic costs of food waste have reached US$750 million per Annam. That is why Sustainable Development Goal 12.3 calls for the importance of food waste management. Wastes of bread represent an important fraction of retail food leftovers. If non-consumed food has been widely valorized in previous years, bread waste is nowadays increasingly of heightened attention. Bread waste can be a promising feedstock for producing bio-conversion value-added products. Recently, several technological methods have been reported for the possibility of transforming bread waste into eco-friendly materials such as ethanol, lactic acid, succinic acid, biohydrogen… etc. This study, based on recent research, sheds light on the possibility to convert food waste, especially bread leftovers into bioethanol by using waste bread as the sole source of nutrients for the growth of Aspergillus niger, which produces glucose, and Saccharomyces cerevisiae, which produces ethanol from glucose (i).

Keywords – Food Waste, Food Waste Management, Bread Waste, Bioethanol, Bread Waste Management

I. Introduction

The soaring price of oil and the increasing amount of greenhouse gas emissions caused by the overconsumption of fossil fuel energies have prompted the worldwide community to seek bioenergy substitutes such as solar, wind, and biomass energies. Waste streams, which are a component of biomass, are now getting a significant chunk of support for sustainable production. Though the global exponential amount of food waste is emerging as a major issue, the latter is now considered a suitable source of added-value materials, which contradicts the approach calling for preventing food waste collection at the source because not all food residues are inedible. Bread waste, for example, can be recycled, handled, and valorized. Several technologies are now being researched in which bread waste is turned into bioethanol. The latter is emerging as the most widely utilized biofuel in the twenty-first century, particularly in transportation and the synthesis of chemical feedstocks. It has therefore demonstrated its effectiveness by resolving certain severe environmental difficulties, such as reducing the detritus of greenhouse gas emissions, as well as economic ones by serving as the future alternative trend to fossil fuel energy.

II. DEFINITION OF WASTE FOOD

There is no unanimous definition of food waste term. Food-related waste is referred to by terms like “food loss,” “food waste,” and “surplus food” (1). However, there are various definitions, and there are ongoing discussions about what constitutes food waste (1) (2).

FAO has provided the following definitions to make clear what "food losses" and "food waste" mean (3):

- Food losses (FL) are reductions in food quantity or quality that occur during the production and distribution phases of the food supply chain (FSC). These losses are primarily dependent on the way the institutional and legal structures that support the food production and supply system are functioning.

- Food waste (FW) is a component of food loss related to the FSC of food elimination (either processed, semi-processed, or raw) that has been opted for consumption, or carelessly let to deteriorate or run out, primarily but not exclusively by the household final consumers.

According to the EU FUSIONS project, food waste refers to "any food, and unsuitable for eating elements of food, that is removed from the food supply chain to be recuperated or removed" (which includes composting, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill, or discarded to sea) (4).

However, food waste can be defined as any type of food produced for people to eat but not consumed (5). It can be also described as the one deserved for eating though it is still disregarded (1).

Food waste and food surplus are distinct things. Food produced more than what is needed for nourishment results in food surplus, and waste is a byproduct of food surplus(6). As a result, there is a pressing need to prevent food waste and recycle it so that people can eat it (1).

To sum up, terms such as food loss, food waste, and "surplus food are terms that are used differently but all of them need to be recycled for eating even food recycle still disregarded in some situations.

III. FOOD WASTE MANAGEMENT

Food waste has become among the most twenty-first century shaped inquiries Food is produced at a rate of 1.3 billion metric tons annually, according to a study by the Food and Agriculture Organization of the United Nations (FAO) [13]. According to a UN analysis, households, grocery stores, and food services companies collectively waste 931 million tons of food annually, raising the possibility that the actual amount of food wasted globally may be more than twice as high as previously thought. In actuality, a number of elements in the supply chain affect waste. According to the UN Environment Programme (UNEP) Food Waste Index Report, 61% of food waste occurs in households, 26% in the food service industry, and 13% in retail [14].

While it is ideal to stop the production of food waste at the source, some waste cannot be prevented (such as bones, shells, and husks). If recycling is an option, food waste that cannot be avoided should be. Instead of being burned at waste-to-energy facilities, food waste can be recycled into useful materials or products like animal feed, compost or fertilizer, non-potable water, or biogas for energy production. Homogeneous food waste, including spent grains, okara, bread, and fruit and vegetable waste, has the potential to be transformed into goods with higher value, such as animal feed and cleaning agents. Additionally, separating food waste for treatment has additional advantages, such as lowering pest 0and odor problems on the property and preventing contamination of drinking water (7).

Fig1. Food waste management hierarchy(Stefano Ghinoi, et.al.2020)

Food treatment is treated through the following steps (32):

Step 1: Identify the locations within your premises where food waste is generated : Common locations include kitchens (where food preparation waste such as vegetable trimmings are generated) and dishwashing or tray-return areas (where post-consumer food waste is collected).

Step 2: Decide the location(s) to segregate food waste :Food waste segregation point(s) can be located independently or co-located with existing waste collection points within the premises, such as bin centres or tray-return areas.

Step 3: Set up a segregation process at identified locations(s) : Designate sufficient space for food waste segregation and collection and employ resources to support food waste segregation and collection.

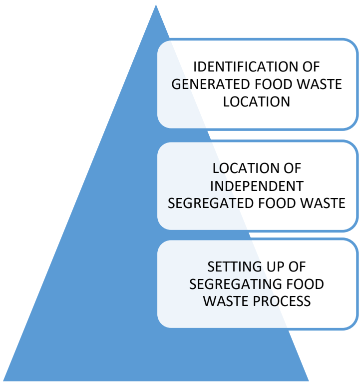
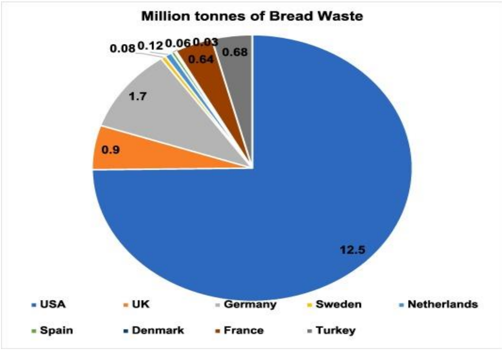


Fig.2 steps of food waste management

A. *Bread Waste Management*

One of the food waste categories with the highest rates is bread. Given that it is a staple food, estimates suggest that 100 million tons of bread are produced worldwide each year, with hundreds of tons being wasted every day (15). Bread waste (BW) is a significant contributor to global food waste (Fig. 1) and a major issue in Europe, where it accounts for the majority of market share (53.6%) (16). The astounding levels of BW not only result in the loss of goods but also the exploitation of numerous natural resources, including water, land, and energy, as well as the production of raw materials, final products, and transportation (16). Additionally, BW, like all food waste, significantly damages the environment overall through eutrophication, acidification, and global warming (17).



B.

C. Fig.3 percentages of bread waste in some world countries (Vinod Kumar, et.al.2023)

As a result, in recent years, managing food waste and providing it value has been in spotlight in order to handle approximately 1.2 million tons of abandoned bread each year (21) and avoid millions of metric tons of greenhouse gas (GHG) emissions as well as billions of money in spending.. Furthermore, various initiatives have been initiated to study novel methods of reusing bread leftovers and converting them into fuel and chemicals like as bioethanol, biohydrogen, succinic acid, and a number of added-value products that can be used in a variety of sectors (29).

B.From Bread Waste to Bioethanol Production

Bioethanol ,with a $58 billion global market, is seen as a promising bio energy source with the potential to be utilized as a gasoline additive and feedstock in the chemical sector (30). Bioethanol is a fermentative obtained from edible feedstocks like starch (corn) simple sugar (cane sugar), and lignocellulosic (wheat straw) biomass. Current waste streams are rich in fermentable carbon, where simple sugar is extracted, have become extremely attractive for biorefineries usges. Food, bakery, bread, and fruit wastes, for example, are abundant low-hanging fermentable sugars fruits , which can be successfully converted to ethanol by Saccharomyces cerevisiae (9)(10) (11). Bioethanol is one of the most used biofuels in this century. It can be generated by fermenting and saccharifying various biomasses in facilities called biorefineries, which also process other bioproducts like biofuels and biochemicals (20) (21). In essence, bioethanol is a renewable energy source that lessens the greenhouse gas emissions from fossil fuels. One practical method for producing bioethanol is from the biomass of leftover food (22) .

The biofuel production process, from hydraulysis to fermentation, is known to be time-consuming and costly. However, when leftover breads are employed in the enzymatic hydrolysis process solid-state fermentation, this procedure can be executed at a lower cost. The University of Manchester in the United Kingdom was the first to develop such an ethanol production technology.(23)

Knowing that bread waste is composed of 50–70% starch, a homopolysaccharide made up of the two sugars amylose and amylopectin. Amylose is a linear polymer of glucose-subunits connected by α-(1 – 4) glycosidic or 1,4′-O(α-glycopyranoside) bonds. The branching chain polymer known as amylopectin is composed of 95% glucose linked by α-(1 – 4) linkages, with the remaining 5% connected by α-(1 – 6) glycosidic bonds. The hydrolysis of these α-(1 – 4) and α-(1 – 6) linkages is necessary for the conversion of starch into discrete glucose units, and it can be accomplished by the action of an acid (H2SO4/HCl) or an enzyme (-amylase and glucoamylase) (18) (19).

A high percentage of glucose is required to produce a large amount of ethanol from bread trash. For high ethanol production, the amount of glucose generated must be substantial, which can be accomplished by raising the enzyme concentration, temperature, and agitation speed, as well as increasing the hydrolysis time (24). In compared to batch culture, fed-batch culture potentially increases glucose conversion yield by over 92%, and solid-state fermentation can be employed to lessen the risk of catabolite suppression. (25) . Bread scraps are regarded as the greatest alternative for usage in this type of technique. Because of its nutrient-rich solid surface, it is ideal for solid-state fermentation of microorganisms (26).

The fungus Aspergillus produces the enzyme glucoamylase for starch hydrolysis in standard biorefineries (27). The same is true for solid-state fermentations that are quite similar to Aspergillus' natural habitat, where it secretes enough protease enzyme to absorb and utilize proteinaceous substrates (23),(26),(28). These enzymes hydrolyze gluten-free wheat, resulting in carbon and nitrogen-rich streams. The hydrolysate is easily converted to ethanol through fermentation using brewer's yeast Saccharomyces cerevisiae, which produces a high amount of ethanol (28).

VI.CONCLUSION

The piled up of food waste management should be the among main focuses of the international community in order to minimize the the annual large amount of food residues, to save the environment from greenhouse gae emissions , to reduce fuel costs , to create new added- value materials,and to realize a global sustainable development. New methods have proved the feasibility of food wastes, sach as waste of bread, to be transformed into organic acids, glucose and fructose syrups, , ethanol, biohydrogen…. Etc. This study , based on research results showing the feasibilty of bread lefovers to be converted to ethanol, encourages local governments to allocate a significant portion of their strategies to bread waste bio-conversion to produce eco-freindly added-value products as well as bioenergy.

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