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UTILIZATION OF WASTES FOR THE PRODUCTION OF SINGLE CELL PROTEIN (SCP).

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(A REVIEW)

SUMMARY

In Nigeria, industries especially petroleum, food, agricultural and pharmaceutical generate a lot of wastes at one stage or the other during processing. These wastes cause hazards to the environment and human health if not disposed off appropriately. Chemical or physical treatment of wastes incure additional capital, operating costs and subsequent disposal without economic gain. Although there are no accurate data in Nigeria on the quantities of wastes generated annually, the wastes could be a rich and inexpensive potential source of raw materials for the production of different products. One of such products is single cell protein. Single cell protein is a microbial cell harvested for human food and animal feeds. SCP has been produced from molasses, corn steep, liqour, cobs and stalks, animal dung, peels of plantain and yam, wastes water from different food industries, rice straw and refinery effluents using various microbial organisms like Canadida utilis and Geotrichum candiduni.

Proper management of wastes available for production of single cell protein will mitigate waste disposal problem and provide an alternative source of protein supplement for human food and animal feeds in Nigeria.

INTRODUCTION

Every fermentation plant utilizes raw materials which are converted to a variety of products. Depending on the individual process, varying amounts of a range of wastes are generated which may include unconsumed organic acids, inorganic media components, wastes wash water and water from cleansing of traces of solvent, acids, homage sewage (Peter and Allan, 1984). If these wastes are not treated and properly disposed off they pollute the environment, especially aquatic ecosystem and cause alteration of the microbiological and physiochemical properties of the ecosystem.

a number of processing it may be possible to recover waste materials as solids l sell it as a by-product which may be an animal feed supplement or a nutrient to used in fermented media (Peter and Allan, 1984). Recently, some countries rticularly, developing countries like Nigeria are also using agro-industrial wastes r production of alternative fuel: ethanol and methenol for cooking purposes siegbu and Ogbonna, 1995).

Another way of utilizing wastes is the production of single cell protein (SCP). esides, SCP can be used as supplement for human and animal feed.

his paper reviews the production of SCP utilizing various wastes.

IATURE AND TYPE OF INDUSTRIAL WASTES

'he nature of industrial waste discharge depends on the type of material the ndustry produces. Wastes produced by the textile industry have characteristically iigh concentration of chemicals and intense colouration derived from the dyes, ibrous material, toxic organic chemicals and heavy metals (Ndagi, 1989). Wastes from oil refineries contain oil, grease and heavy metals. The hydrocarbon components form about 75% of the total component of oil and they include aliphatic, aromatic and alicyclic hydrocarbons. Oil and its wastes from oil producing areas of Delta region of Nigeria devastate the environment.

Soft drink plants which are scattered all over the country have wastes water similar to that of the breweries except that they may have less suspended solids and odours since malt is not used. Effluent may however, be caustic due to the nature of chemicals used. Effluent from the automobile industries such as peugeot Assembly plant in Kaduna have high level of solid, high turbidity and intense colouration. The waste water contains metals, particularly lead, emanating from painting and scrap metals. Other sources of metal are chemical industries that emit mercury and lead, which are discharged from factories to water bodies through its waste and may be taken with water directly or by consumption of fish (Ndagi, 1989).

In paper industry, lignocellulosic wastes consist of cellulose (50%), hemicellulose (28%) and lignin and other components (22%). Cellulose and hemicellulose are all polymers of glucose and other sugar such as xylose. Hemicellulose are those polysaccharide covalently associated with cellulose.

In fruit juice industry, apple pomace wastes consists of a press cake resulting from processing apples. In general, it is an acid substrate with a considerable buffering capacity, rich in carbohydrates and low in protein content. A rapid spoilage caused by micoorganisms can start because of a high moisture content of fresh pomace.

Grain wastes, e.g rice wastes, sorghum, millet wastes generally are sources of carbohydrate which literally mean simple sugars and disaccharides, maltose and hexose.

PRODUCTION OF SINGLE CELL PROTEIN (SCP)

Microorganisms may serve as food for human beings or feed for animals. Although a number of kinds of microorganisms have been recommended for human consumption including biomass not only of single cell organisms, such as yeasts, bacteria and unicellular algae, but also coenocytic multicellular moulds (Dasilva et al, 1987; Frazier and Westhoff, 1994).

MICROORGANISMS AND SUBSTRATES USED FOR THE PRODUCTION OF SCP

As shown in Table 1. yeasts, bacteria, fungi, and algae are the stable agent for SCP production using various wastes as substrates.

CONDITIONS GROWTH AND PRODUCTION

Numerous processes are used for the production of SCP, but this discussion will be limited to the use of yeasts for SCP production. Yeasts produced by continuous process requires:

1. establishment of active yeast growth in the fermenter.
2. feeding of carbohydrates and sources of nitrogen, phosphorus and potassium at increasing rates until a maximum level of yeast growth is maintained continuously.
3. application of optimal aeration and agitation and
4. withdrawal of liquor (beer) containing the yeast cells at rates and volume e.g equalling the addition of fresh medium (Frazier and Westhoff, 1994).

Optimal conditions for yeast production vary with the yeast employed and the substrates used. Aeration should be considered at an optimal level; too little substrates encourages alcohol production rather than growth, and too much favours increased respiration and heat reduction and hence lowered yield of the yeast cells. The optimal temperature depends upon the yeast strain. The pH should be kept on the acid side usually 4.5 and 6.0. The concentration of fermentable sugar is maintained at a level not higher than that nécessary for good yield of cells. The amount and kind of inorganic nutrients to be added depends upon the substrats. Cane or beet sugar molasses, for example, is usually high in potassium and fairly well supplied with available phosphorus and nitrogen, but spent sulphite liquor is deficient in three of these element, which are needed in relative amount . Nitrogen is added in the form of ammonia or ammonium salts. The yeasts are killed before use. Special pre-treatments are required before some of the substrates can be used to cultivate yeast. SCP used for animal feed can also be produced using solid state fermentation (Wainwright,1992).

ADVANTAGES AND CRITICISMS OF SCP.

The advantages of the use of SCp include:

i. Possibility of using a non-human food as substrate for scp production.

ii. Inherent high protein content of microorganisms on a dried weight basis/ protein contents might approach 60to70 percent of the cell.

iii. Rapid increase in cells (protein) because of the extremely short generation time, and

iv. Lack of dependence of the SCP production processes on climatic conditions (Frazier and Westhoff, 1994).

The disadvantages of using wastes for the production of SCP are:

(a) Wastes, particularly paper mill sludge, is deficient in potassium, phosphorus and nitrogen and these elements are needed in relatively large amount for the microbial cells to grow well.

(b) The pre- treatment cost of paper mill and wood hydrolysate is very expensive.

(c) Large amount of nucleic acids are produced by cells e.g microorganisms that show a high growth rate. Excessive consumption of these SCP leads to kidney stone formation or gout. (Wainwrigh,1992).

NUTRITIONAL VALUE AND SAFETY CONTROL OF SINGLE CELL PROTEIN (SCP).

Nutritive values of SCP vary with the type of microorganisms and the substrates used. SCP produced from either petroleum hydrocarbons or methanol are characterised by a high and well balanced content of essential amino acids, particularly; L-lysine, L-tryptophan and L-isoleucine which are the main limiting amino acids in cereals. They are rather low in the thio-aminoacids (Methionine and cysteine), but only to the same extent as soyabeans Senez (1986) . Routine digestibility expressed as a percentage ranges from 65-96% for the various culture tested, while the routine efficiency ratio. (RER) values range from 0.6-2.6 (approx.) Frazier and Westhoff (1988). They also reported that the methods of harvesting, drying and processing have marked effects on the nutritive values of the finished products.

GUIDELINES FOR TESTING THE NUTRITIONAL VALUE AND SAFETY OF SCP IN HUMAN FOOD AND ANIMAL FEED.

The protein advisory Group of the United Nations (PAG) in 1974 and revised in 1983 (PAG/UNU1983) has summarised the guidelines as follow:

a) Prolonged ingestion of nucleic acids in yeast (5-6%) and bacteria (10-13%) increases Uricaemia and intestinal problems in some predisposed individuals (senez,1986).

b) From extensive studies performed at the Massachuseffs Institute of Technology (MIT) (Garattini et al. 1979), it was concluded that a daily intake of nucleic acid up to 2.0g is completely safe. This limit corresponding to 25g of dry yeast, would be sufficient to provide a most significant supply of protein in the diet.

(c) Humans have been fed on a mixture of algae protein, *chlorella* and *scenedesmus* 100g/day for 3-6 days. When increased to 200g/day, gastroenteritis, nausea, vomitting and diarrhoea occurs. Feeding trials with bacteria protein have not been successful in man. But dry fungal cells have adjudged as better tolerated up to 135g/day for 9 days without side effect (Frazier and Westhoff, 1988).

(d) Efforts to reduce the nucleic acid content of SCP is being developed. Mild cutaneous (skin reactions) and or gastro-intestinal troubles resulting in nausea and vomitting have been reported in consumers of some SCP products, but can be prevented by appropriate modification of industrial processing (Scrimshaw and Udall 1983).

The success of utilization of microbial protein to meet human needs coupled with an expanding world population would necessitate an increased reliance on SCP for the biosynthesis of useful compounds. The conversion of wastes into a valuable product, reduces pollution and waste treatment costs.

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Table 1.0Production of SCP from different wastes.

Substrates (Wastes)	Micro-organisms	References
Gas oil	* *Candida tropicalis*	(a)
Methanol	B *Methylomonas*	(a)
Methane	B *Pseudomonas*	(a)
	B *Methylococcus*	
Molasses	* *Candida utilis*	(a)
	* *Saccharomyces cerevisiae*	(b)
Molasses and starch wastes	B *Corynebacterium melassicola*	(a)
	B *Brevibacterium lactofermentum*	
	* *Schwanniomyces castelli*	(b)
Corn wastes	+ *Trichoderma viride*	(a)
Orange peels	* *Geotrichum candidum*	(b)
Confessionery wastes	* *Candida utilis*	(a)
Milk whey coconut water	* *Kluyveromyces fragilis*	(b)
Apple pomace	* *Kleokera apiculata*	(c)
	* *Candida utilis*	
Skin of green plantain	+ *Pichia spartinae*	(d)
Cassava starch effluent	* *Endomycopsis fibuliger* and	(c)
	* *Candida utilis*	
Cassava starch	* *Geotrichum candidum*	(g)
Culture pond	^ *Spirilina maxima* and	(f)
	Scenedesmus acutus	(f)

(a)Dasilva et al. (1987)* - Yeast (b)Wainwright (992) + - Fungi (c)Rahmat et al. (1995)B - Bacteria (d)Fior and Susan (1983)A – Algae (c)Manilal et al. (1991) (f)Frazier and Westhoff (1994)