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Production of an Eco-Feed through SSF from Recycled Banana Waste (Peel)

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Abstract

Food industry in general, generates a large quantity of waste (peel, seed, pomace) which is biodegradable in nature. Due to its richness in carbohydrate, crude fiber, minerals, such wastes have the potential to support the growth of microorganisms involved in the production of various products. Banana chips and banana fig are the main products from banana flesh produced by a number of small and medium factories located nationwide. As industrial by-products, peels represent about 30-40 g/100 g of the fruit weight. The banana peel waste is normally disposed in municipal landfills, which contribute to the existing environmental problem. Laboratory scale solid state fermentation of wastes from banana processing industry revealed the possibility of production of nutritious eco-feed. SSF of banana peel by *Aspergillus niger* and removal of ethanol by direct distillation method showed increase in nutrient composition of fermented banana peel which can be used as a feed.

Keywords: banana peel, banana fig, solid state fermentation, ethanol, eco-feed, *Aspergillus niger*

1. Introduction

The global shortage of food and feed protein has prompted researchers to seek protein production improvements from both conventional and unconventional sources. One promising unconventional source is the mass cultivation of microbial biomass using renewable substrates which occur abundantly in nature. The use of fermentation processes to produce microbial biomass has several advantages over other unconventional processes that rely on agricultural byproducts, including the fact that fermentation processes are not subjected to the variability of weather conditions and they can be controlled for product quantity and quality in virtually any geographic location. In particular, solid substrate fermentation (SSF) offers numerous advantages for the production of proteins because of its high productivity, low cost media, less effort in downstream processing and products with added nutritional market value. Much of the research is focused on the value-addition of agricultural products by SSF using agricultural residues generated every year (Biniyam Yalemtesfa, *et al.,* 2010).

Banana is the second largest produced fruit after citrus, contributing about 16% of world's total fruit production. India is the largest producer of banana, contributing 27% of world's banana production. In India, Tamil Nadu is the leading producer of banana, followed by Maharashtra. *Musa sapientum* which is commonly called banana is an herbaceous plant of the family *Musaceae*. Considering the upsurge in the prices of livestock feeds and their increasing demand, this study was conducted to provide information about the chemical composition and nutritional qualities of *Musa sapientum* peel which is often ignored and considered as waste could be domesticated for proper utilization as livestock feeds (Tinnagon Tartrakoon, *et al.,* 1999).

In Nigeria, studied the chemical composition of banana peels. *Musa sapientum* peels were analyzed for minerals, nutritional and anti – nutritional contents. The result of mineral content indicated the concentrations (mg/g) of potassium, calcium, sodium, iron, manganese, bromine, rubidium, strontium, zirconium and niobium to be 78.10, 19.20, 24.30, 0.61, 76.20, 0.04, 0.21, 0.03, 0.02 and 0.02 respectively. The percentage concentrations of protein, crude lipid, carbohydrate and crude fiber were 0.90, 1.70, 59.00 and 31.70 respectively. The results indicate that if the peels are properly exploited and processed, they could be of high-quality and cheap source of carbohydrates and minerals for livestock (Anhwange, B.A. *et al.* 2007).

The present study was undertaken to reveal the possibility of production of value added product such as animal feed through solid state fermentation from banana peel. The fruit wastes have been accumulating in soil and potentially causing serious environmental problems, therefore the aim of this work is not only to produce animal feed but to treat the wastes.

2. Materials and Methods

2.1. Collection of the banana peel

For this purpose we had collected a total of 45 gm of banana peel from the fruit market situated in Nasik. These were washed & rinsed well in distilled water.

2.2 Preparation of the substrate for the fermentation process

Banana peels were oven dried for 2-3 days. Then samples were ground into small particles and weighed, which was 20 gm.

2.3 Solid state fermentation

Solid state fermentation was done by the method of Biniyam Yalemtesfa, *et al.,* 2010. 0.12 gm ammonium sulphate was added into ground banana peel substrates which were autoclaved at 121^{O}C. Fungal suspension culture (1 single disc of fungus) was inoculated into 20 ml sterile distilled water. Then fermentation was carried out at 25-30^{O}C for 7 days.

2.4 Product recovery by distillation

Direct distillation was done by the method of Joshi V. K. and Devrajan, 2007**.**Fermented product was transferred to the conical flask. After adding equal volume of water, flask was directly kept on heater followed by distillation and one third volume was distilled. Product was kept on mechanical dehydrator at 60^{O}C for 1 day. Packaging was done and further biochemical analysis was carried out.

2.5 Carbohydrate estimation

Carbohydrate was estimated by Hedge, J. E. and Hofreiter, B. T. 1962. 100 mg sample (raw and fermented each) was taken in a boiling tube. It was hydrolyzed by keeping in boiling water bath for 3 hrs in 2.5 ml of 2.5 N HCl and cooled at room temperature. Then it was neutralized with solid sodium carbonate until effervescence ceased. Volume was made up to 100 ml and centrifugation was carried out, supernatant was collected and 1 ml aliquot was taken for analysis. Then std. was prepared by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 ml of working std. and blank and volume was made up to 1 ml in all tubes by adding distilled water.4 ml anthrone reagent was added and was heated for 8 min. in water bath, then allowed to cool rapidly, O.D was taken at 630 nm and concentration of both samples were determined.

Amount of CHO in 100 mg sample = [mg of glucose / vol. of test sample] X 100

2.6 Protein estimation

Protein was estimated by Bradford method. Standard protein series were prepared using BSA (1%) diluted with 0.15 M NaCl.5 standards were prepared by taking 0, 1, 2, 3, 4, 5 ml of BSA. 2 samples (raw and fermented each) were taken and volume was made up to 5 ml in all tubes, followed by addition of 1 ml Bradford reagent and kept for 5 min. Then O.D was taken and concentration of both samples were determined by plotting the graph.

2.7 Determination of ash content

The ash content was determined by dry ashing method. Two gm fermented sample was weighed accurately previously heated at 100^{O}C.It was placed on clay pipe triangle and heated on low flame till completely charred, and then it was ignited in muffle furnace at 500^{O}C for 3-5 hrs. It was allowed to cool and weighed. It was then ignited again at 500^{O}C for 30 min, cooled in desiccator and weighed .Procedure was continued till weight was constant.

(% Ash (Dry basis) = [Mash / Mwet] X 100)

Mash = mass of ashed sample

Mwet = mass of original sample

2.8 Amino acid estimation

Amino acid was estimated by Ninhydrin method. Standard series of amino acid stock 0 to 1 ml was prepared in 0.2 M acetate buffer (Alanine, serine, Threonine, Aspartic acid and Glycine) and 2 samples (raw and fermented each) were also prepared in the same buffer. Volume was made up to 4 ml with distilled water. Then 1 ml reagent was added and boiled for 15-20 min and O.D was taken and concentration of both samples was determined.

3. Results & Discussion

3.1. Solid state fermentation

Figure 1 and 2 shows better growth of fungus on moist solid substrate (banana peel) after 7 days of inoculation.

Figure 1: Product development after fermentation

Figure 2: Product development after fermentation

Solid-state fermentation has emerged as a potential technology for the production of microbial products such as feed, fuel, food, industrial chemicals and pharmaceutical products. Due to its richness in carbohydrates, crude fiber, minerals such fruit waste have ability to support the growth of microbes for product development. Here growth of *Aspergillus niger* has been seen clearly on banana waste. (Joshi, V. K. and Devender Attri 2006).

3.2 Direct distillation

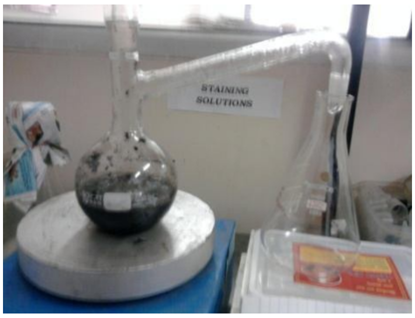

Figure 3: Direct distillation of banana peel

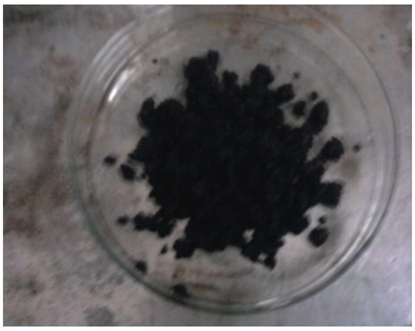

Figure 4: Final product after distillation

Figure 3 and 4 shows direct distillation for the recovery of fermented product and final product obtained after distillation respectively. The chemical characteristics of dried banana peels residue after recovery were evaluated for knowing nutrient composition (Joshi, V. K.and Devrajan 2007).

3.3 Crude fiber estimation

Crude fiber consists largely of cellulose and lignin (97%) plus some mineral matter. It represents only 60% to 80% of the cellulose and 4% to 6% of the lignin. The crude fiber content is commonly used as a measure of the nutritive value of poultry and livestock feeds. The content of crude fiber was found to be 16% and 33.5% in unfermented and fermented product respectively. The value of fermented product has greater concentration than unfermented product, which indicates that fermented product could help to improve general health and well being.

3.2. Carbohydrate estimation

Banana peels are good source of pectin (10-21%), cellulose (7.6-9.6%) and hemicelluloses (6.4-9.4%). Pectin extracted from banana peel also contains glucose, galactose, arabinose and xylose (Debabandya Mohapatra *et al*.). Figure 5 show content of carbohydrates, in which fermented and unfermented samples showed 0.69 and 0.67 mg/ml concentration respectively. The value indicates that fermented sample has slightly more concentration than unfermented sample. Value of fermented product indicates that it could be a good source of carbohydrate (Anhwange, B.A. *et al*.2009).

3.4 Protein Estimation

Protein content was estimated by Bradford method, which was found to be 0.033 and 0.057 gm/ml in unfermented and fermented product respectively. Fermented product showed greater concentration. Peel is a rich source of proteins, so it plays an important role in improving the animal health (Debabandya Mohapatra.*et.al*.2010).

3.5 Amino acid estimation

Concentration of alanine in fermented and unfermented product was found to be 0.26 and 0.18 mg/ml respectively, which indicated that fermented product, had greater concentration of alanine than unfermented product. Concentration of serine in fermented product was 0.33 mg/ml, while unfermented product contained about 0.23 mg/ml, less than the fermented product. Concentration of threonine was found to be 0.21 and 0.14 mg/ml was found in fermented and unfermented product respectively. Concentration of aspartic acid found in fermented product was 0.39 mg/ml, while unfermented product contained 0.27 mg/ml.Glycine was found to be about 0.30 and 0.21 mg/ml respectively in fermented and unfermented product. Amino acids like alanine, serine, threonine, aspartic acid and glycine were found in greater concentration in fermented product, which plays an important role in animal metabolism. Banana peels contain all essential amino acids higher than FAO standard (Debabandya Mohapatra *et.al*.2010).

4.7 Moisture and ash content

Moisture content of fermented sample was found to be 3.42 %. The value is relatively slow, but it designated that the fermented product can be amassed for long time without growing moldy. The ash content was found to be 17.5%, this value is analogous to other staples measured as good source of minerals (Anhwange, B.A. *et al*.2009).

Conclusion

In the present study, the growth of *Aspergillus niger*, in an aerated vessel of moist banana peel powder was studied. The study dealt with both the microbial and physical aspects of the system. For the validation of the physical models in this study, experiments were carried out in a vessel. To provide better surface area peels were ground to small particles due to which fungi got penetrated easily, also vessel & substrate was autoclaved to avoid risk of contamination. Incubation of fungal suspension was carried out aseptically, after proper incubation for 7 days. Recovery of fermented product was carried out by direct distillation method & biochemical tests were carried out which showed increase in nutrient composition of fermented product than raw product.

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