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ORIGINAL ARTICLE

Solid-state Fermentation of Cassava (*Manihot esculenta*) Peels Using *Rhizopus Oligosporus*: Application of the Fermented Peels in Yeast Production and Characterization of α-amylase Enzyme Produced in the Process

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Abstract
Solid-State Fermentation (SSF) of cassava peels was studied using *Rhizopus oligosporus*. Several biochemical parameters of the fermented cassava peels extract (FCPE) were determined. The applicability of the FCPE as nutrient source for *Saccharomyces cerevisiae* (yeast) growth was also investigated. There was a significant ($p < 0.05$) decrease in glucose, reducing sugar concentrations, in vitro antioxidant capacity and an increase in soluble protein content across the pH range (5–9) in FCPE when compared with the unfermented control. The fermented cassava peels supported higher growth of yeast ($O.D_{600nm}$, 0.465 ± 0.005) than the unfermented cassava peels ($O.D_{600nm}$, 0.113 ± 0.001), probably due to its higher protein content. α-Amylase was produced extracellularly from *R. oligosporus* during the fermentation process with an optimum substrate concentration of 1%w/v starch and optimum contact time of 30 min. The optimal temperature and pH of the partially purified enzyme were 60 °C and pH 7, respectively, with V_{max} and K_m values of 17.36 Units/mL and 0.33%w/v. Ca^{2+} increased the activity of the enzyme, but Na^{+} and Al^{3+} inhibited its activity. Sodium dodecyl sulphate (SDS) and ethylene diamine tetra acetic acid (EDTA) also inhibited the enzyme. The findings of the present study could serve as a precursor data source for protein, α-amylase and yeast production by allied industries such as animal feeds and biotechnology industries.

Keywords Solid state fermentation · *Rhizopus oligosporus* · Cassava peels · α-Amylase · Biochemical characterization · Yeast production

1 Introduction

Solid state fermentation is a relevant, initial approach for bioconversion of lignocellulose to other useful products that are usually more easily digestible when used as feeds for farm animals or as nutrient source for microorganisms [1–3]. It is, therefore, helpful in making use of wastes and by-products from food and agricultural industries for production of various important products [4–9].

Cassava (*Manihot esculenta* Crantz) is a very important food crop in Nigeria and many tropical countries. In processing of fermented cassava products, cassava roots are usually peeled to remove the double outer coverings which are: a thin brown outer covering, and a thicker leathery parenchymatous inner covering [10]. The peels of cassava are considered as wastes and normally thrown away to decay. The peels of cassava can make up 20 to 35% of the tuber's total weight [11]. Presently, the generated cassava wastes present a disposal problem. Such disposal issue would even become a bigger issue in the nearest future, especially with the increased manufacture of cassava products [10, 12–14]. Since they could constitute

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