
# Research Journal of Microbiology

ISSN 1816-4935

Academic
Journals Inc.

www.academicjournals.com

Research Journal of Microbiology 10 (11): 533-541, 2015
ISSN 1816-4935 / DOI: 10.3923/jm.2015.533.541


# Nutrient Enrichment of Mannanase-Treated Cassava Peels and Corn Cob

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## ABSTRACT

This study aimed at the examination of nutrient enrichment of cassava peels and corn cob through mannanase treatment. Mannanase production was conducted using Locust Bean Gum (LBG) as the sole carbon source; moisten with mineral salt solution and enzyme activity determined by dinitrosalicylic acid. Crude mannanase was concentrated by ammonium sulphate. The samples were hydrolyzed with concentrated mannanase within a sealing system. The chemical compositions of enzyme treated-samples were determined according to standard chemical methods. The mineral compositions of the enzyme-treated samples were determined using atomic absorption spectrophotometer method. The result obtained showed an increase in crude protein from 5.34±0.17% in non-enzyme treated corn cob to 9.61±0.98% in enzyme treated corn cob. The enzyme treated samples showed a markedly reduction in crude fiber by 13.75 and 29.70% for cassava peels and corn cob respectively. The lignin (9.49%), cellulose (68.75, 33.06 and 10.82%) and hemicellulose (55.38 and 9.64%) contents decreased in enzyme treated samples for cassava peels and corn cob. Cyanide decreased significantly in all the mannanase-treated samples. Mineral composition varied significantly with treatment type and the substrate treated. The treatment of cassava peels and corn cob with mannanase resulted in the degradation of the complex carbohydrate fractions in the samples to increase its crude protein and certain minerals contents.

**Key words:** Mannanase, cassava peels, corn cob, fibre composition, nutrient enrichment

## INTRODUCTION

Mannanase of microbial origins has been shown to improve feed bioconversion and performance of broilers, fish, turkeys and swine in recent years (Jackson *et al*., 1999). It plays an important role in the breakdown of mannosidic bonds in the main chain of β-mannan, galactomannans, glucomannans and galactoglucomannans into manno oligosacharides and small amount mannose, glucose and galactose (Olaniyi *et al*., 2014). The treatment of copra meal rich in β-mannan with mannanase had been documented and reported to increase the metabolizable energy and improve the nutrient digestibility (Khanongnuch *et al*., 2006). The treatment of palm kernel meal by mannanase initiated an increase in its nutritive values (Olaniyi *et al*., 2014). In addition, enzymatic treatment of palm kernel meal by commercial enzymes induced an appreciable increase in the weight gain of broiler chicks, feed conversion efficiency, dry matter digestibility and

nutrient digestibility, while the jejuna content viscosity was decreased (Sundu *et al*., 2006). Manno oligosaccharides (MOS), one of the major by-products of β-mannan hydrolysis by mannanase was found to be an excellent substrate for the proliferation of beneficial bacteria and it could prevent the colonization of *Escheria coli* and Salmonellae, leading to an improvement of animal growth performance (Ishihara *et al*., 2000; Khanongnuch *et al*., 2006).

The dependency on agricultural wastes to offset the fluctuating global market price of conventional feed ingredients (such as fishmeal) for livestock production have been the focus of developing countries. Nigeria is the world top producers of cassava and corn. Africa as a continent accounts for more than 90% of the global cassava production in 2004 (Aro, 2008) with Nigeria contributing 38.4 million metric tones and coming up from the third position behind Brazil and Zaire in the Eighties to being the largest producer of cassava in the world today. The utilization of cassava and its by-products has enjoyed widespread patronage in the formulation livestock feeds (Aro, 2008). Cassava peels are wastes generated by mechanical removal of the 2 outer coverings of cassava roots prior to its subsequent processing to other cassava products like starch, flour, chips, "Gari," "Fufu" etc. (Aro *et al*., 2008). These peels are left to rot in the environment constituting unwholesome pollution in spite of their great nutritive values especially for livestock feeding. The limitations to the use of cassava peels in livestock nutrition are their high fibre content, low calorific value and their heavy loads of anti-nutrients like cyanide, tannins and phytates (Aro, 2008). Maize corn is the central rachis to which the grain are attached and which remains as an agro-industrial waste after threshing. Maize cob residue is an organic material consisting primarily of lignocelluloses and other extractives (Busari *et al*., 2013) and hence subject to microbial degradation like other organic plant wastes. Bioconversion is an alternative for productive utilization of discarded maize cob. Recently, fermentation of the agricultural wastes such as maize cobs with fungi has gained considerable attention because it is necessary to increase the world food and feed supplies especially those high in protein and most of the nutritionally valuable metals with small amount of anti-nutrient content (Busari *et al*., 2013). Thus, this study aimed at the examination of nutrient enrichment of cassava peels and corn cob through mannanase treatment.

## MATERIALS AND METHODS

**Microorganisms:** *Penicillium italicum* was provided by the culture collection of Research Laboratory, Federal University of Technology, Akure, Ondo State, Nigeria. The strain whose origin was yam peels was selected based on its previous performance in terms of mannanase activity on Locust Beans Gum (LBG) (Arotupin and Olaniyi, 2013). The identity of the strain was authenticated through cultural characters and microscopic structure. The culture was maintained on LBG agar medium slant at 4°C throughout the study.

**Substrate collection:** Cassava peels and corn cob treated with concentrated mannanase were procured from open farm fields located in Akure, Ondo State, Nigeria. The wastes were oven-dried at 70°C for 2 h with Model DHG Heating Drying Oven for a period of 2 h and stored in air tight transparent plastic containers to keep it moisture free.

**Medium preparation and mannanase production:** The production of mannanase in solid state fermentation was conducted using 250 mL Erlenmeyer flasks containing 10 g LBG. The substrate (LBG) was suspended in 33 mL Mandels and Weber's medium modified by Olaniyi *et al*. (2014).

This medium (moistening agent) contained the following ingredients (g $L^{-1}$): Peptone 2, yeast extract 2, $NaNO_3$ 2, $K_2HPO_4$ 1, $MgSO_4.7H_2O$ 0.5, KCl 0.5 and $FeSO_4.7H_2O$ traces. After sterilization at 121°C for 15 min, it was cooled and inoculated with 2 discs of 8 mm diameter of the fungal strain. The flask was incubated at room temperature for 5 days at static condition.

**Mannanase extraction:** The solid state cultures were prepared by adding 10-fold (v/w) 0.1 M phosphate buffer (pH 6.8) and shaking (180 rpm) at 30°C for 60 min. The fungal biomass was separated by centrifugation (Centurion Scientific Limited) (6000 rpm, 15 min at 4°C).

**Mannanase assay:** Mannanase activity was assayed in the reaction mixture composing of 0.5 mL of 1% LBG prepared in 50 mM potassium phosphate buffer pH 6.8 and 0.5 mL of supernatant at 45ºC for 60 min (modified method of Olaniyi *et al*. (2014)). The control tube contained the same amount of substrate and 0.5 mL of the enzyme solution heated at 100°C for 15 min. Both the experimental and control tubes were incubated at 45°C for 60 min. At the end of the incubation period, tubes were removed from the water bath (Lamfield Medical England Model DK-600) and the reaction was terminated by addition of 2 mL of 3, 5-dinitrosalicylic acid (DNSA) reagent per tube. The tubes were incubated for 5 min in a boiling water bath for colour development and were cooled rapidly. The activity of reaction mixture was measured against a reagent blank at 540 nm. Amount of reducing sugar released was determined by the dinitrosalicylic acid reagent (DNS) (Miller, 1959). One unit of mannanase activity was defined as amount of enzyme producing 1 μ mole of mannose per minute under standard assay conditions.

**Preparation of Mannanase Treated Cassava Peel (MTCP) and Mannanase Treated Corn cob (MTCC):** The extracellular mannanase was harvested after 5 days of cultivation by centrifugation with $3.62\times10^3$ g for 20 min at 4°C and the supernatant obtained was used as crude enzyme solution. The supernatant was brought to 30% ammonium sulphate concentration and re-centrifuged for 20 min. The supernatant collected was further brought to 70% ammonium sulphate concentration and re-centrifuged for another 20 min (Adebiyi *et al*., 2008). The sediment, that is, the precipitate was taken as the enzyme. For every 100 mL of the solution that was spun in the centrifuge, the precipitate was suspended in 5 mL phosphate buffer at pH 6.8. The samples (cassava peels and corn cob) were hydrolyzed with concentrated mannanase at 30°C for 60 h (36 g each of CP and CC was separately suspended in 200 mL distilled water plus 12 mL of enzyme preparation with an activity of 69.36 U $mL^{-1}$) within a sealing system (modified method of Khanongnuch *et al*. (2006)). After completion of the reaction, the product was completely dried by vacuum dryer at 65°C for 60 h to obtain the MTCP and MTCC (Khanongnuch *et al*., 2006).

**Chemical composition of Mannanase Treated Cassava Peel (MTCP) and Mannanase Treated Corn Cob (MTCC):** The chemical composition of MTCP and MTCC and non-enzymatic treated CP and CC (NMCP and NMCC) were determined by standard methods according to AOAC (2005). Fiber compounds including Acid Detergent Fibre (ADF), Neutral Detergent Fibre (NDF) and Acid Detergent Lignin (ADL) contents were measured sequentially with a fiber automatic analyzer (Fibertec System, M, Tecator, Hoganas, Sweden) (Van Soest *et al*., 1991). Hemicellulose was calculated as NDF-ADF, cellulose as ADF-ADL, while lignin content is obtained by the subtraction of residue after extraction from ash. Phytate was determined through the extraction of the samples with hydrochloric acid and sodium sulphate and absorbance measured at 660 nm

(De Boland *et al*., 1975). Tannin was determined using the method of vanillin hydrochloric acid and absorbance was measured at 500 nm (Price *et al*., 1978). Oxalate determination was done according to the standard method of Day and Underwood Jr. (1986), while cyanide content was evaluated by the method of Obadeni and Ochuko (2002).

**Mineral composition of Mannanase Treated Cassava Peel (MTCP), Mannanase Treated Corn Cob (MTCC), Non-Mannanase Treated Cassava Peel (NMCP) and Non-Mannanase Treated Corn Cob (NMCC):** The mineral composition of mannanase and non-mannanase treated CP and CC was determined using the atomic absorption spectrophotometer method as described by AOAC (2005).

**Statistical analyses:** The statistical analysis was performed using the general linear model function of Statistical Package for Social Science (SPSS), version 16.0. All data generated was subjected to one-way ANOVA while statistical differences of treatment were determined using Duncan's Multiple Range.

## RESULTS

The effect of concentrated mannanase of *P. italicum* on proximate composition of CP and CC was evaluated (Table 1). There were no siginificant differences ($p<0.05$) in ash content and crude protein between mannanase-treated cassava peels and untreated substrate. Mannanase treatment of cassava peels showed significant reduction in moisture content, fat content and crude fibre. The moisture content, fat content and crude fibre of mannanase-treated cassava peels had 31.65, 271.12 and 13.75% reduction respectively in comparison with untreated sample. The crude protein, ash and fat content of mannanase-treated corn cob increased significantly ($p<0.05$) from 5.34±0.17%-9.61±0.98%, 1.15±0.13% -1.79±0.01% and 1.04±0.06%-4.18±0.05% respectively. The moisture and crude fibre content of mannanase-treated corn cob increased significantly by 28.36 and 29.70% respectively.

The result of mannanase treatment from *P. italicum* on the anti-nutrient composition of MTCP and MTCC (mg $g^{-1}$ dry weight) is shown in Table 2. The mannanase-treated wastes showed significant decrease ($p<0.05$) in cyanide in all the treatments when compared with untreated samples. The cyanide content of cassava peels and corn cob decreased in mannanase-treated wastes from 15.81±0.16 mg $g^{-1}$-5.01±0.34 mg $g^{-1}$ and 11.69±0.02 mg $g^{-1}$-3.92±0.12 mg $g^{-1}$ respectively. There was no significant decrease in phytate content of mannanase-treated cassava peels. The phytate content decreased in mannanase-treated corn cob by 30.73% in comparison with the control experiments. The tannin and oxalate content of mannanase-treated wastes varied significantly between the treatments. There was no significant difference in tannin content between mannanase-treated cassava peels and corn cob and the untreated samples.

Table 1: Proximate composition of MTCP and MTCC (% dry weight)

| Wastes | Moisture | Ash | Crude fibre | Crude protein | Fat |
|---|---|---|---|---|---|
| **MTCP** | | | | | |
| Untreated | 14.21±0.27$^{c}$ | 5.59±0.04$^{a}$ | 25.90±0.30$^{c}$ | 5.90±0.24$^{a}$ | 0.89±0.77$^{a}$ |
| During treatment | 10.28±0.11$^{b}$ | 5.53±0.45$^{a}$ | 23.26±0.13$^{b}$ | 5.48±0.13$^{a}$ | 2.18±0.12$^{b}$ |
| After treatment | 9.15±0.43$^{a}$ | 6.06±0.41$^{a}$ | 22.34±0.44$^{a}$ | 5.77±0.33$^{a}$ | 3.30±0.32$^{c}$ |
| **MTCC** | | | | | |
| Untreated | 13.55±0.44$^{c}$ | 1.15±0.13$^{a}$ | 58.18±0.56$^{c}$ | 5.34±0.17$^{a}$ | 1.04±0.06$^{a}$ |
| During treatment | 11.26±0.07$^{b}$ | 1.34±0.02$^{b}$ | 51.74±0.12$^{b}$ | 7.26±0.07$^{b}$ | 3.42±0.04$^{b}$ |
| After treatment | 9.71±0.22$^{a}$ | 1.79±0.01$^{c}$ | 40.90±0.67$^{a}$ | 9.61±0.98$^{c}$ | 4.18±0.05$^{c}$ |

Values are Means±SE (n = 3). Means with the same superscript letters down the same column are not significantly different ($p<0.05$), MTCP: Mannanase treated cassava peel, MTCC: Mannanase treated corn cob

Table 2: Anti-nutrient composition of mannanase treatment of *P. italicum* on MTCP and MTCC (mg $g^{-1}$ dry weight)

| Wastes | Phytate | Oxalate | Tannin | Cyanide |
|---|---|---|---|---|
| **MTCP** | | | | |
| Untreated | 11.81±0.49$^{ab}$ | 0.32±0.05$^{a}$ | 0.13±0.01$^{a}$ | 15.81±0.16$^{c}$ |
| During treatment | 11.53±0.31$^{a}$ | 0.35±0.01$^{ab}$ | 0.12±0.00$^{a}$ | 9.40±0.04$^{b}$ |
| After treatment | 12.38±0.00$^{b}$ | 0.41±0.05$^{b}$ | 0.12±0.00$^{a}$ | 5.01±0.34$^{a}$ |
| **MTCC** | | | | |
| Untreated | 10.71±0.00$^{c}$ | 0.32±0.05$^{b}$ | 0.05±0.01$^{a}$ | 11.69±0.02$^{c}$ |
| During treatment | 8.15±0.07$^{b}$ | 0.26±0.02$^{ab}$ | 0.05±0.00$^{a}$ | 5.17±0.02$^{b}$ |
| After treatment | 7.42±0.00$^{a}$ | 0.22±0.05$^{a}$ | 0.05±0.00$^{a}$ | 3.92±0.12$^{a}$ |

Values are Means±SE (n = 3). Means with the same superscript letters down the same column are not significantly different ($p<0.05$), MTCP: Mannanase treated cassava peel, MTCC: Mannanase treated corn cob

Table 3: Fibre composition of mannanase treatment of *P. italicum* on CP and CC (% dry weight)

| Wastes | Lignin | Cellulose | Hemicellulose |
|---|---|---|---|
| **CP** | | | |
| Untreated | 12.75±0.73$^{b}$ | 43.29±0.40$^{c}$ | 13.75±0.02$^{c}$ |
| During treatment | 12.14±0.17$^{ab}$ | 18.23±0.96$^{b}$ | 10.23±0.03$^{b}$ |
| After treatment | 11.54±0.24$^{a}$ | 13.53±0.40$^{a}$ | 9.21±0.38$^{a}$ |
| **CC** | | | |
| Untreated | 24.30±0.55$^{c}$ | 52.22±0.80$^{c}$ | 9.44±0.36$^{a}$ |
| During treatment | 23.13±0.01$^{b}$ | 46.43±0.09$^{b}$ | 9.28±0.06$^{a}$ |
| After treatment | 21.67±0.25$^{a}$ | 28.92±0.69$^{a}$ | 8.53±0.71$^{a}$ |

Values are means± S.E (n = 3). Means with the same superscript letters down the same column are not significantly different ($p<0.05$), CP: Cassava peel, CC: Corn cob

Table 4: Mineral composition of mannanase treatment of *P. italicum* on CP and CC (ppm)

| Wastes | Calcium | Magnesium | Zinc | Phosphorus | Copper | Potassium |
|---|---|---|---|---|---|---|
| **CP** | | | | | | |
| Untreated | 1.25±0.01$^{b}$ | 0.13±0.01$^{a}$ | 0.03±0.01$^{c}$ | 0.19±0.01$^{a}$ | 0.38±0.00$^{c}$ | 7.40±0.45$^{c}$ |
| During treatment | 1.24±0.02$^{b}$ | 0.18±0.01$^{b}$ | 0.01±0.01$^{b}$ | 0.43±0.04$^{b}$ | 0.12±0.01$^{b}$ | 4.38±0.04$^{b}$ |
| After treatment | 1.06±0.01$^{a}$ | 0.36±0.01$^{c}$ | 0.00±0.00$^{a}$ | 1.43±0.02$^{c}$ | 0.08±0.01$^{a}$ | 1.57±0.01$^{a}$ |
| **CC** | | | | | | |
| Untreated | 2.56±0.01$^{c}$ | 0.77±0.00$^{a}$ | 0.02±0.01$^{a}$ | 0.06±0.00$^{a}$ | 0.37±0.01$^{c}$ | 3.40±0.01$^{c}$ |
| During treatment | 1.15±0.05$^{b}$ | 0.79±0.01$^{a}$ | 0.09±0.01$^{b}$ | 0.95±0.03$^{b}$ | 0.22±0.01$^{b}$ | 2.08±0.07$^{b}$ |
| After treatment | 0.76±0.02$^{a}$ | 0.92±0.03$^{b}$ | 0.17±0.01$^{c}$ | 2.36±0.03$^{c}$ | 0.06±0.00$^{a}$ | 1.66±0.01$^{a}$ |

Values are Means±S.E (n = 3). Means with the same superscript letters down the same column are not significantly different ($p<0.05$), CP: Cassava peel, CC: Corn cob

The result of mannanase treatment from *P. italicum* on the fibre composition of CP and CC (% dry weight) is shown in Table 3. The mannanase-treated wastes showed significant decrease ($p<0.05$) in lignin and cellulose content in all the treatments when compared with untreated samples. The lignin content of cassava peels and corn cob decreased in mannanase-treated wastes from 12.75±0.73%-11.54±0.24% and 24.30±0.55%-21.67±0.25% respectively. The cellulose content of mannanase-treated wastes decreased from 43.29±0.40%-13.53±0.40% in cassava peels and 52.22±0.80%-28.92±0.69% in corn cob. There was no significant reduction in hemicellulose content of mannanase-treated corn cob. The hemicellulose content of mannanase-treated cassava peels reduced by 33.06% in comparison with control experiment.

Mannanase treatment from *P. italicum* on mineral composition of wastes (ppm) is shown in Table 4. The mineral composition varied significantly with treatment type and the substrate treated. The mannanase-treated wastes showed significant decrease ($p<0.05$) in calcium and copper content in all the treatments when compared with untreated samples. The calcium content of enzyme-treated cassava peels and corn cob decreased from 1.253±0.01-1.057±0.01 pmm and 2.563±0.01-0.757±0.02 ppm respectively. The copper content of enzyme-treated cassava peels

and corn cob decreased by 78.22 and 83.65% respectively. The magnesium content increased significantly in mannanase-treated cassava peels and corn cob when compared with untreated samples. The phosphorus content increased significantly in all the mannanase-treated wastes.

## DISCUSSION

The mannolytic potential of *P. italicum* had been documented and it had been recommended as the choice organism for β-mannan bioconversion processes (Arotupin and Olaniyi, 2013; Akinyele *et al*., 2013). Filamentous fungi have been reported to biodegrade varieties of agricultural wastes through the secretion of extracellular enzymes (phytases, mannanases, xylanases, cellulases, tannanases, lipases, pectinases and proteases) (Akinyele and Agbro, 2007; Parani and Eyini, 2010). Khanongnuch *et al.* (2006) treated copra meal with mannanase for the formulation of broiler diet, Jackson *et al*. (1999) treated corn-soybean meal with β-mannanase and evaluate its effects on laying hen performance, while Saenphoom *et al*. (2011) evaluated effect of β-mannanase treatment on chemical composition of palm kernel expeller.

Concentrated mannanase form *P. italicum* was able to break down mannan content of cassava peels and corn cob and improved their nutritive values. There was significant ($p<0.05$) increase in the crude protein of mannanase-treated samples when compared with control treatment. In the research conducted by Khanongnuch *et al.* (2006), crude protein increased from 5.84% for non-enzyme treated copra meal (control) to 6.01% in mannanase-treated sample. The increase in crude protein was attributed to the release of proteins from lipid-protein-polysaccharide complex of the copra meal. Similar observation was also made by Teves *et al.* (1989) when copra meal was treated by bacterial mannanase. The crude protein content of the control (untreated sample) and enzyme treated palm kernel meal were not significantly different in a study conducted by Saenphoom *et al*. (2011). However, Liu and Baidoo (1997) reported that crude protein content of fungal fermented palm kernel cake increased nearly 2 folds (16.8-31.2%), while no significant increase in crude protein was detected in enzyme treated palm kernel cake. The authors suggested that the increased crude protein could be due to microbial protein synthesis during fermentation. The increase in crude protein value of the degraded cassava peels and corn cobs might partly be due to the ability of the enzyme to increase the bioavailability of the protein hitherto encapsulated by the cell walls. According to Bachtar (2005), the fungal enzymes have the potentials of improving not only the Non Starchy Polysaccharides (NSPs) but also of protein as well as other dietary components, such as fatty acids. Secretion of proteinase along side with enzyme of interest by fungi invariably increases the protein content of feed materials. Many workers have reported similar increase in protein content. Iyayi and Aderolu (2004) reported increase in crude protein when *A. niger* was inoculated on sago fiber and cassava fibre resulting into 16.5 and 18.5% protein increase respectively. The author reported a 21.9% increase in the protein content of cocoa shell when inoculated with *A. niger*. Ofuya and Nwajiuba (1990) reported increases in crude protein of 31, 36 and 41% with *A. niger*, 26, 33 and 38% with *A. flavus* and 27, 36 and 32% with *Penicillium* sp. in brewer's dried grain, maize offal and wheat offal, respectively after 14 days of their biodegradation. Results of other workers (Albores *et al*., 2006; Lawal *et al*., 2010; Akinfemi, 2012) suggested the ability of fungi inoculated on low quality feed ingredients to increase the protein levels in such ingredients by the conversion of the carbon atom of the broken down carbohydrates into mycelia protein.

There were significant reductions ($p<0.05$) in moisture and crude fiber contents in the enzyme-treated samples compared to the control. The enzyme-treated samples showed a markedly

reduction in crude fiber. The significant reduction in crude fiber contents indicates that the enzyme is effective in breaking down mannan-hemicellulose, the component of the fiber in cassava peels and corn cobs (Lawal *et al*., 2010; Saenphoom *et al*., 2011).

There were significant reductions in cyanide, phytate and tannin content of enzyme treated samples. The reduction in the anti-nutritional compounds in enzyme treated sample could be due to the action of certain hydrolytic metabolites produced along side with the enzyme of interest (Nwafor and Ejukonemu, 2004; Aro, 2008; Akinfemi, 2012). Reduction in the anti-nutrient compounds were reported by (Ojokoh *et al*., 2012) for fermented groundnut and popcorn, fermented cassava tuber (Aro, 2008), fermented sorghum cultivars (Wedad *et al*., 2008) and fermented canola meal (Omid *et al*., 2012).

Lignin, cellulose and hemicellulose (fiber compounds) contents decreased significantly ($p<0.05$) in enzyme-treated samples compared to the control. The result obtained in this study is in agreement with Albores *et al*. (2006) who found that the fungal enzyme-treated palm kernel cake reduced lignin, hemicellulose and cellulose contents resulted in increased crude protein and soluble sugar (glucose, fructose, galactose and sucrose) contents. The reduction in fiber compounds (lignin, cellulose and hemicelluloses) of enzyme-treated samples could be attributed to the ability of the fungi to secrete hydrolyzing and oxidizing enzymes, which could convert the recalcitrant compounds in the wastes into utilizable compounds (Ahmad *et al*., 2000; Akinfemi, 2012).

The mineral analysis of enzyme-treated samples showed significant increase in magnesium and phosphorus content compared with untreated samples. Similar observations were reported by Ojokoh *et al*. (2012) and Akinyele *et al*. (2011) for fermented products and it was attributed to the fact that some of these metals could be part of some biological macromolecules which were released into the solution from such structures during fermentation.

## CONCLUSION

The treatment of cassava peels and corn cobs with mannanase resulted in the degradation of complex carbohydrate fractions in the samples to increase their crude protein and certain minerals contents. There was also reduction in some anti-nutrient compounds in enzyme-treated samples.

## REFERENCES

AOAC., 2005. Official Methods of Analysis. 18th Edn., AOAC., Washington, DC., USA., pp: 426-428.

Adebiyi, A.O., I.C. Oladipo, A.A. Ayandele, A.P. Adebiyi and O.O. Adelowo, 2008. Biological studies on albino rats fed with *Sorghum bicolorstarch* hydrolyzed with *α*-amylase from *Rhizopus* sp. Afr. J. Biotechnol., 7: 1999-2005.

Ahmad, T., S. Rasool, M. Sarwar, Ahsan-ul Haq and Zia-ul Hasan, 2000. Effect of microbial phytase produced from a fungus *Aspergillus niger* on bioavailability of phosphorus and calcium in broiler chickens. Anim. Feed Sci. Technol., 83: 103-114.

Akinfemi, A., 2012. Chemical composition and nutritive value of fungal treated acha straw. Agric. Sci. Technol., 4: 120-124.

Akinyele, B.J. and O. Agbro, 2007. Increasing the nutritional value of plantain wastes by the activities of fungi using the solid state fermentation technique. Res. J. Microbiol., 2: 117-124.

Akinyele, B.J., O.O. Olaniyi and D.J. Arotupin, 2011. Bioconversion of selected agricultural wastes and associated enzymes by *Volvariella volvacea*: An edible mushroom. Res. J. Microbiol., 6: 63-70.

Akinyele, J.B., O.O. Olaniyi and C.O. Adetunji, 2013. Screening and optimization of nutritional conditions for mannanase production by Penicillium italicum LAD-A5 in solid state cultivation. E3 J. Biotechnol. Pharm. Res., 4: 35-41.

Albores, S., M.J. Pianzzola, M. Soubes and M.P. Cerdeiras, 2006. Biodegradation of agroindustrial wastes by *Pleurotus* spp. for its use as ruminant feed. Elect. J. Biotechnol., 9: 215-220.

Aro, S.O., 2008. Improvement in the nutritive quality of cassava and its by-products through microbial fermentation. Afr. J. Biotech., 7: 4789-4797.

Aro, S.O., V.A. Aletor O.O. Tewe A.N. Fajemisin B. Usifo and J.A. Adesida, 2008. Studies on the nutritional potentials of Cassava Tuber Wastes (CTW) collected from a factory. Proceedings of the 4th Annual Conference of SAAT, May 21, 2008, Akure, Nigeria, pp: 86-92.

Arotupin, D.J. and O.O. Olaniyi, 2013. Screening and identification of mannanase-producing fungi isolated from selected agricultural wastes. Br. Microbiol. Res. J., 3: 635-644.

Bachtar, M., 2005. Improvement of nutritive of crop by products using bioprocess technique and their uses for animals. J. Feed Technol., 21: 1-5.

Busari, M.B., E.O. Ogbadoyi, O.A.Y. Daudu, I.M. Animashahun, L. Yusuf and A.A. Lateef, 2013. Effect of natural and combined fungal fermentation on phytate, tannin and some mineral contents of corn cobs. Int. J. Applied Biol. Res., 5: 82-89.

Day, Jr.R.A. and A.L. Underwood Jr., 1986. Quatitative Analysis. 5th Edn., Preistice Hall Publication, USA., ISBN: 9780137467280, Pages: 774.

De Boland, A.R., G.B. Garner and B.L. O'Dekk, 1975. Identification and properties of phytate in cereal grains and oilseed products. J. Agric. Food Chem., 23: 1186-1189.

Ishihara, N., D.C. Chu, S. Akachi and L.R. Juneja, 2000. Preventive effect of partially hydrolyzed guar gum on infection of *Salmonella enteritidis* in young and laying hens. Poult. Sci., 79: 689-697.

Iyayi, E.A. and Z.A. Aderolu, 2004. Enhancement of the feeding value of some agro-industrial by-products for laying hens after their solid state fermentation with *Trichoderma viride*. Afr. J. Biotechnol., 3: 182-185.

Jackson, M.E., D.W. Fodge and H.Y. Hsiao, 1999. Effects of β-mannanase in corn-soybean meal diets on laying hen performance. Poult. Sci., 78: 1737-1741.

Khanongnuch, C., C. Sa-nguansook and S. Lumyong, 2006. Nutritive quality of β-mannanase treated copra meal in broiler diets and effectiveness on some fecal bacteria. Int. J. Poult. Sci., 5: 1087-1091.

Lawal, T.E., E.A. Iyayi, B.A. Adeniyi and O.A. Adaramoye, 2010. Biodegradation of palm kernel cake with multienzyme complexes from fungi and its feeding value for broilers. Int. J. Poult. Sci., 9: 695-701.

Liu, Y.G. and S.K. Baidoo, 1997. Exogenous Enzymes for Pig Diets: An Overview. In: Enzymes in Poultry and Swine Nutrition, Marquardt, R.R. and Z. Ha (Eds.)., International Development Research Centre, Canada, ISBN-13: 978-0889368217, pp: 115-128.

Miller, G.L., 1959. Use of dinitrosalicylic acid reagent for determination of reducing sugar. Anal. Chem., 31: 426-428.

Nwafor, O.E. and F.E. Ejukonemu, 2004. Bioconversion of cassava wastes for protein enrichment using amylolytic fungi-A preliminary report. Global J. Pure Applied Sci., 10: 505-507.

Obadeni, B.O. and P.O. Ochuko, 2002. Phytochemical studies and comparative efficacy of the crude extracts of some haemostatic plants in Edo and Delta states of Nigeria. Global J. Pure Applied Sci., 8: 203-208.

Ofuya, C.O. and C.J. Nwanjuiba, 1990. Microbial degradation and utilization of cassava peel. World J. Microbiol. Biotechnol., 6: 144-148.

Ojokoh, A.O., A.B. Abiola and R.T. Lawal, 2012. Changes in nutrient and antinutrient composition of popcorn and groundnut composite flour subjected to solid substrate fermentation. Afr. J. Agric. Res., 27: 3439-3445.

Olaniyi, O.O., D.J. Arotupin, B.J. Akinyele and O.S. Bamidele, 2014. Kinetic properties of purified β-mannanase from *Penicillium italicum*. Br. Microbiol. Res. J., 4: 1092-1104.

Omid, S., F. Mehrdad, C. Chris, Y. Bagher and M.S. Masoomeh, 2012. Study on the effect of solid state fermentation with *Aspergillus niger* on antinutritional factors of canola protein concentrate with aim of using in the diet of rainbow trout (*Oncorhynchus mykiss*). Proceedings of the 11th International and the 4th National Congress on Recycling of Organic Waste in Agriculture, April 26-27, 2012, Isfahan, Iran.

Parani, K. and M. Eyini, 2010. Effect of co-fungal treatment on biodegradation of coffee pulp waste in solid state fermentation. Asian J. Exp. Biol. Sci., 1: 352-359.

Price, M.L., S. van Scoyoc and L.G. Butler, 1978. A critical evaluation of the vanillin reaction as an assay for tannin in sorghum grain. J. Agric. Food Chem., 26: 1214-1218.

Saenphoom, P., J.B. Liang, Y.W. Ho, T.C. Loh and M. Rosfarizan, 2011. Effect of enzyme treatment on chemical composition and production of reducing sugars in palm (*Elaeis guineenis*) kernel expeller. Afr. J. Biotechnol., 10: 15372-15377.

Sundu, B., A. Kumar and J. Dingle, 2006. Palm kernel meal in broiler diets: Effect on chicken performance and health. World's Poult. Sci. J., 62: 316-325.

Teves, F.T., A.F. Zamora M.R. Calapardo and E.S. Luis, 1989. Nutritional value of copra meal treated with bacterial mannanase in broiler diets. Philippine Agric. J., 72: 7-14.

Van Soest, P.J., J.B. Robertson and B.A. Lewis, 1991. Methods for dietary fiber, neutral detergent fiber and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci., 74: 3583-3597.

Wedad, W., H. Abdelhaleem, A.H. El Tinay, A.I. Mustafa and E.E. Babiker, 2008. Effect of fermentation, malt-pretreatment and cooking on antinutritional factors and protein digestibility of sorghum cultivars. Pak. J. Nutr., 7: 335-341.