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Solid State Fermentation of Maize (*Zea mays*) Offal by *Rhizopus oligosporus* under Acidic and Basic Conditions

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Abstract

Maize offal, a by-product of maize milling industry that constitutes environmental pollution is under-utilized. This study investigated the effect of solid state fermentation on maize offal using *Rhizopus oligosporus* under acidic and basic conditions (pH range of 3 to 9). Soluble proteins content, glucose and amylase activity of the fermented by-products were evaluated after five days' period of fermentation. The result showed a significant increase in soluble proteins content at pH 3, glucose at pH 6 and amylase activity at pH 7 when compared with the control ($P < 0.05$). This showed that solid state fermentation improves the nutritional value of maize offal at different pH values. Thus, livestock feeds formulation industries could harness this process in the utilization of maize offal for poultry, other farm animal feeds and food fortification for protein enhancement thereby, preventing environmental pollution.

Keywords: Maize offal; Solid state fermentation; Soluble proteins; Amylase.

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1. Introduction

Maize offal is a by-product of maize milling processes locally or industrially, which is conventionally utilized in livestock feeds formulation in Nigeria [1]. Maize offal contains about 150 g/kg crude protein and 85 g/kg crude fibre [2,3]. The comparatively low crude fibre content with relation to other by-products could be a reason for the utilization of maize offal as livestock feeds. However, the low protein composition appears to be a limitation to its usage by modern livestock feeds formulation industries in Nigeria [1-5]. This has resulted to some degree of environmental pollution orchestrated by inadequate utilization of maize offal by modern feeds formulation industries. Maize offal also constitutes to environmental pollution. Therefore, there is important need for urgent scientific measures that could improve the utilization and protein content of maize offal and bran. By this, livestock feeds formulation industries could harness maize offal and bran for livestock feeds and eventually, reduces environmental pollutions posed by this domestic and industrial waste [6].

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Recent scientific research has been on biotransformation of waste materials of cereals and grains origin into more useful by-products and enriched diets for livestock feeds [7]. The transformed waste materials have also been reported to be major sources of biodiesel and biofuels [6]. Previous studies have also shown that biotransformation of grains enhances the nutritional contents [8,9]. One of the scientific approaches designed for the conversion of waste products of domestic and agro-based industrial origins is the solid state fermentation, in which waste products are subjected to biotransformation through oxidative mechanism. This fermentation process involves the conversion of waste materials of agricultural produce and food processing industries into bio-active by-products in the absence or little volume of water. This promises to be a modern biotechnology for the conversion of domestic and food processing wastes into useful by-products and enriched diets. In Africa and Nigeria in particular, little is known about this process. Therefore, the aim of this study is to evaluate the effect of solid state fermentation on maize offal.

2. Materials and Methods

2.1. *Collection of plant materials*

Maize offals (*Zea mays*) were collected at Abraka community in Delta State in December, 2018 and was identified and authenticated in the Department of Botany, University of Benin, Edo State-Nigeria with a voucher number UBH- Z259. The sample was air-dried for one week. The dried maize offals were then pulverized and stored at room temperature.

2.2. *Solid state fermentation procedure*

Rhizopus oligosporus was obtained from Tonukari Biotechnology, Songhai Amukpe, Sapele, Delta State. 1 g of *R. oligosporus*was moistened with 15 mL of citrate and phosphate buffers ranging from pH 3 to pH 9 in seven different petri dishes which were labelled according to the pH value. To these petri dishes 7 g of the ground maize offal was added, mixed thoroughly, covered and allowed to ferment for 5 days. 3.1 g of the fermented mixture was taken from each of the petri dishes and 40 mL of distilled water was added, mixed and homogenized using a mortar and pestle. 10 mL of the mixture was collected into a test tube, centrifuged for 10 min and the supernatant (crude extract) was stored in a universal container at 4 °C for the various assays.

2.3. *Determination of biochemical parameters*

pH of the media after five days of solid state fermentation was determined using Extect pH meter. Glucose determination was done according to the method described by the Randox glucose kit. Total soluble proteins were determined by means of biuret method as described by Gornal *et al*. [10] and absorbance read at 540 nm. Amylase activity was determined according to the method reported by Avwioroko *et al*. [11,12] using 3,5

dinitrosalicylic acid (DNS) reagent and 0.5% soluble starch solution as substrate. Enzyme activity was expressed as µg of maltose released by the enzyme per gram of the sample per minute.

2.4. *Statistical analysis*

All data were subjected to statistical analysis. Values were reported as mean ± standard deviation and the experimental results were analyzed using analysis of variance (ANOVA). The results were considered significant at p-values of less than 0.05, using Dunnett's T3 multiple comparisons test.

3. Results and Discussion

Solid state fermentation has played a significant role in combating environmental pollution by indiscriminate dumping of domestic and industrial wastes by converting them to economically valued added products. Maize offal was fermented by *R. oligosporus* for five days at different pH; pH 3 to 9. The result of the final pH is shown in Fig. 1. While the unfermented sample had a pH of 4.7, the samples that were fermented at pH 3 to 9 had their final pH between pH 5.1 to 6.7 except for fermentation pH 4 and 5 that had final pH close to neutral pH (7.1 to 7.7). This suggests that solid state fermentation using *R. oligosporus* reduced the level of acidity in maize offal. According to Nwachukwu [4], fermentation reduces the level of acidity in cereals. Therefore, this finding validates the report of Nwachukwu [4]. It is also in agreement with previous studies of Oyarekua [8].

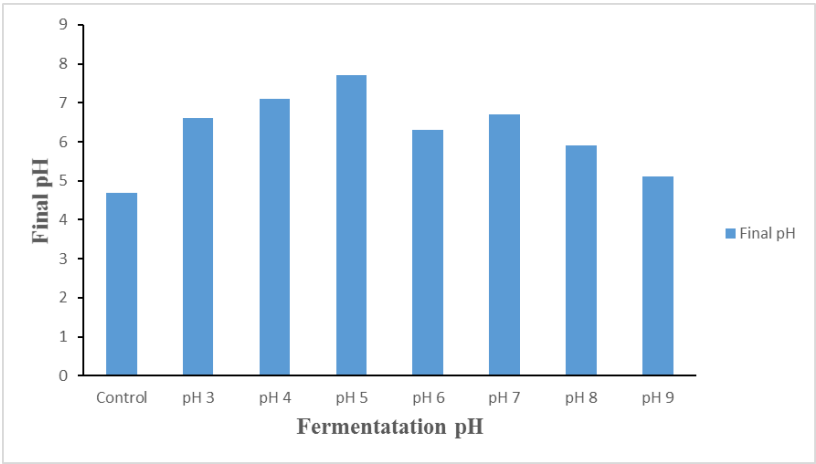

Fig. 1. Final pH value of *R. oligosporus* solid state fermented maize offal after fermentation.

The results of the effect of fermentation pH ranging from 3-9 after five days of solid state fermentation of maize offal with *R. oligosporus* on soluble proteins are presented in Fig. 2. In all the fermentation pH studied, there was a significant increase in soluble protein

when compared with the control. However, highest soluble protein content was seen in maize offal fermented at pH 3. This showed that solid state fermentation of maize offal with *R. oligosporus* increased the crude protein content. A marked increase was observed at pH 3 with protein content of 421.73±3.00 mg/g when compared with the control 203.87±13.30 mg/g. This is an indication that solid state fermentation improved the protein content of maize offal. Therefore, solid state fermentation enhanced the nutritional composition of maize offal. This report is consistent with previous studies [13-16].

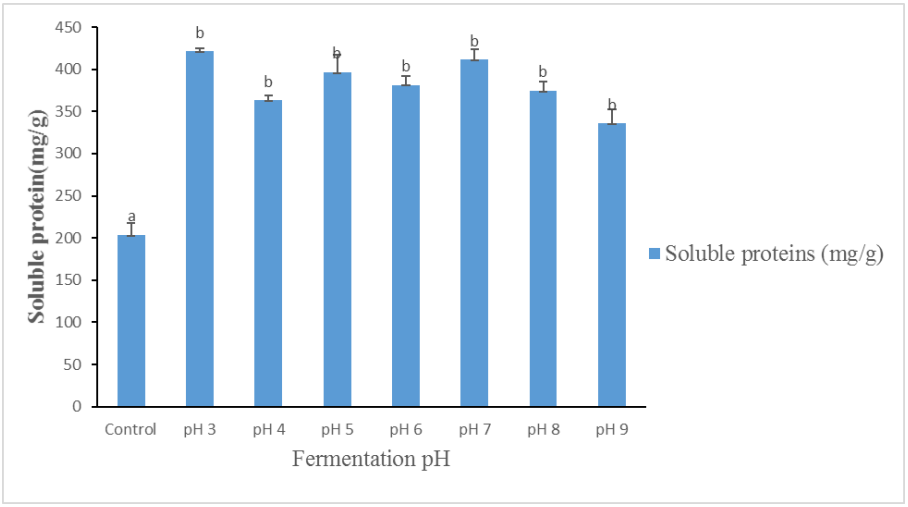

Fig. 2. Soluble protein content (mg/g) of the *R. oligosporus* solid state fermented maize offal. Values are expressed as means ± standard deviations of triplicate determinations. Bars bearing small letter 'b' differed from the control (a) significantly ($p < 0.05$).

Similarly, solid state fermentation of maize offal improved the glucose content (Fig. 3). There was a general marked increase in glucose content in all the pH investigated when compared with the control. Highest glucose content of 6.20 ± 1.24 mg/g in relation with the control (0.73±0.16 mg/g) was observed in maize offal fermented at pH 6. This is a clear indication that slight acidic medium favors the production of glucose by the organism. This could be due to the favorable state of the fermentation processes at pH 6 [17,18]. This suggests that slightly acidic and basic medium speed up the production or synthesis of glucose as the enzyme amylase functions optimally at pH of 6. According to Oyarekua [8], this report is in biochemical consonance with previous report. Again, it agrees with the report of Herbert [3].

Amylase activity markedly increase at all the fermentation pH studied (Fig. 4). The enzyme activity was highest at fermentation pH 7 (509.04 ± 24.33 µg/g/min**)** when compared with the control. This may probably be due to the suitable environment created by the pH as well as activators of the enzyme present in the medium [19,20]. This report also agrees with the work of Aruna *et al*. [21].

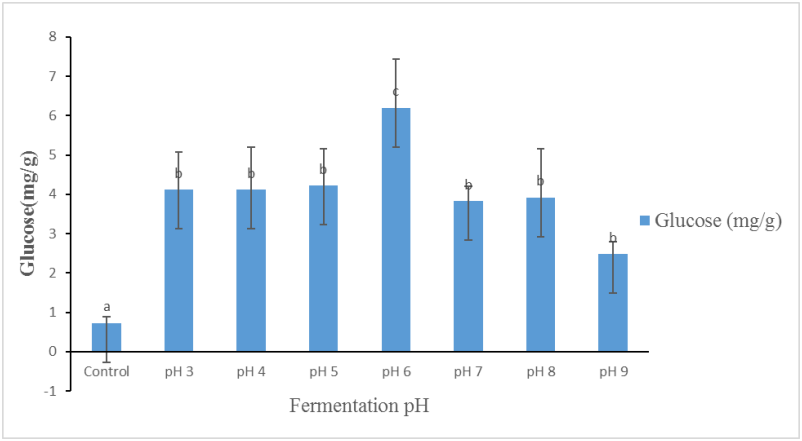

Fig. 3. Glucose content (mg/g) of the *R. oligosporus* solid state fermented maize offal. Values are expressed as means ± standard deviations of triplicate determinations. Bars bearing small letter 'b and c' differed from the control (a) significantly ($p<0.05$).

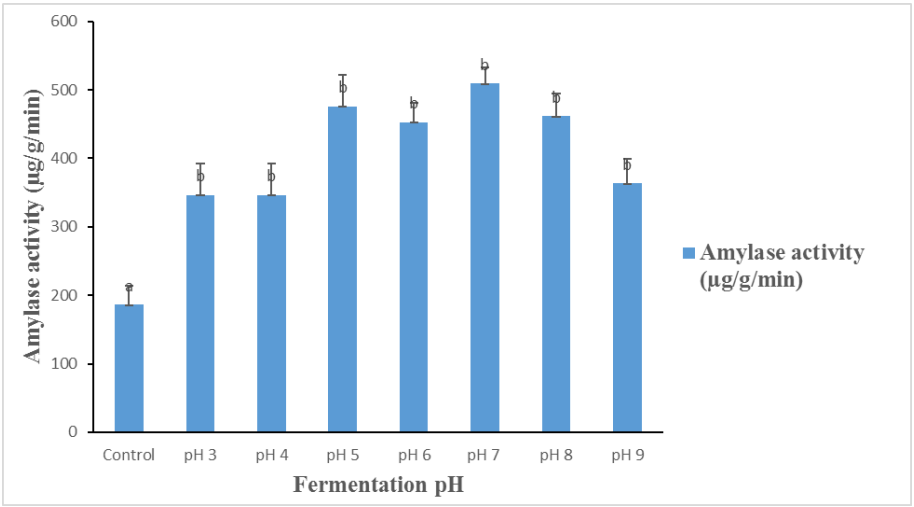

Fig. 4. Amylase activity of *R. oligosporus* solid state fermented maize offal. Values are expressed as means ± standard deviations of triplicate determinations. Bars bearing small letter 'b' differed from the control (a) significantly ($p < 0.05$).

4. Conclusion

In conclusion, the overall result of this study shows that solid state fermentation of maize offal with *R. oligosporus* improves the nutritional value (proteins, glucose), and amylase activity. This process could enhance the use of maize offal for livestock feeds, single cell protein (SCP) production. By bioconversion of these waste products of maize and other

cereals processing industries into value added by-products, the environmental pollution posed could be reduced drastically.

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References

1. A. O. Adelekan and N. C. Nnamah, J. Food Process Technol. **10**, 1000783 (2019).
2. O. A. Makinde and E. B. Sonaiya, Open J. Animal Sci. **1**, 106 (2011). https://doi.org/10.4236/ojas.2011.13014
3. K. D. Herbert, Poultry Sci. **1,** 2 (2017). https://doi.org/10.5772/65363
4. E. Nwachukwu, O. K. Achi, and I. O. Ijeoma, Afr. J. Food Sci. Technol. **1**, 21 (2010).
5. N. J. Tonukari, T. Ezedom, C. C. Enuma, S. O. Sakpa, O. J. Avwioroko, L. Eraga, and E. Odiyoma, Am. J. Plant Sci. **6**, 972 (2015). https://doi.org/10.4236/ajps.2015.67103
6. N. F. Obi, B. O. Ugwuishiwu, and J. N. Nwakaire, Nig. J. Technol. **35**, 957 (2016). https://doi.org/10.4314/njt.v35i4.34
7. M. A. Oyarekua, Int. J. Curr. Microbiol. Appl. Sci. **5**, 267 (2016).
8. M. A. Oyarekua, Afr. J. Food Agri. Nutr. Dev. **13**, 7171 (2013). https://doi.org/10.18697/ajfand.56.4285
9. K. Abegaz, Afr. J. Bacteriol. **6**, 1469 (2007).
10. A. G. Gornall, C. J. Bardawill, and M. M. David, J. Biol. Chem. **177**, 751 (1949).
11. O. J. Avwioroko, N. J. Tonukari, and S. O. Asagba, Adv. Biochem. **3**, 15 (2015). https://doi.org/10.11648/j.ab.20150301.14
12. O. J. Avwioroko, A. A. Anigboro, A. S. Ejoh, F. O. Atanu, M. A. Okeke, and N. J. Tonukari, Biocatal. Agri. Biotechnol. **21**, ID 101298 (2019). https://doi.org/10.1016/j.bcab.2019.101298
13. A. M. Omemu, O. B Oyewole, and M. O. Bankole, Food Microbiol. **24**, 571 (2007). https://doi.org/10.1016/j.fm.2007.01.006
14. A. I. Sanni, S. Sefa-Dedeh, E. Sakyi-Dawson, and M. Asiedua, Int. J. Food Sci. Nutr. **53**, 367 (2002). https://doi.org/10.1080/0963748021000044705
15. H. A. Khalil, Afr. J. Biotechnol. **5**, 206 (2005).
16. M. A. Oyarekua, J. Food Technol. **1**, 1 (2015).
17. N. J. Tonukari, E. E. Oliseneku, O. J. Avwioroko, E. Aganbi, O. C. Orororo, and A. A. Anigboro, Afr. J. Biotechnol. **15**, 776 (2016). https://doi.org/10.5897/AJB2015.15181
18. N. J. Tonukari, O. J. Avwioroko, and T. Ehwerhemuepha, Scientific Res. Essays **5**, 826 (2010).
19. O. J. Avwioroko, A. A. Anigboro, and N. J. Tonukari, Biotechnol. J. Int. 1 (2016).
20. O. J. Avwioroko, A. A. Anigboro, N. N. Unachukwu, and N. J. Tonukari, Biochem. Biophys. Reports **14**, 35 (2018). https://doi.org/10.1016/j.bbrep.2018.03.006
21. T. E. Aruna, O. C. Aworh, A. O. Raji, and A. I. Olagunju, Ann. Agric. Sci. **62**, 33 (2017). https://doi.org/10.1016/j.aoas.2017.01.002