Effect of Solid State Fermentation on Phytochemical Composition of Rice Bran Meal

ABSTRACT

In aquaculture, the available feed ingredients are expensive and limited in quantity making it essential to explore fish feed ingredients that are low-cost and locally available. Agroby-products seems to be one of the available source.This studyevaluate the effect of solid state fermentation on phytochemical compositions of rice bran meal. Rice bran was collected in three different containers, ground into powder, then sieved and fermented using solid state fermentation procedure. Each sample was solidly fermented (wet at 10% moisture and keep in fermenter at ambient temperature) for 24 hours (1 day), 96 hours (4 days), and 168 hours (7 days). Afterward, the fermented samples were oven dried for one hour at 100^{o}C as described. The fermented samples were taken to the laboratory for phytochemical analysis. The results obtained from this study revealed that fermenting rice bran for seven days (168hrs) using solid state fermentation method reduced the Alkaloid contain from 12.61±1.04mg/kg to 10.24±1.52mg/kg, 9.18±0.11mg/kg and 8.13±0.16mg/kg.Phytate from 6.73±1.32mg/kg to 4.39±0.82mg/kg, 4.05±0.56mg/kg and 2.15±0.73mg/kg. Tannins from 4.60±0.13mgTA/kg to 4.11±0.65mgTA/kg, 3.26±0.47mgTA/kg and 1.52±0.24mgTA/kg.Saponins from 2.98±0.54g/kg to 2.50±0.17g/kg, 1.88±1.54g/kg and 1.43±1.17g/kg.Oxalate from 2.78±1.25mg∞/100g to 2.47±1.42mg∞/100g, 2.91±0.31mg∞/100g and 1.82±0.13mg∞/100g. However, it increases Flavonoids from 6.94±1.82mgRutin/kg to 7.90±1.35mgRutin/kg, 9.03±0.43mgRutin/kg and 11.18±1.35mgRutin/kg. Phenols from 1.71±0.32gGAE/kg to 2.14±0.12gGAE/kg, 2.91±1.53gGAE/kg and 3.58±1.65gGAE/kg. This study establishesthe fact that, fermented rice bran meal can be incorporated as an essential part of the feed production in order to reduced cost of production thereby increasing the profit and enhances waste management.

Keywords: RiceBran Meal; Solid-State Fermentation and Phytochemical Composition.

1. INTRODUCTION

"The high cost of fish feed has been recognized as a major factor militating against rapid development of aquaculture in the developing countries due to the fact that most of the conventional feedstuffs being used in human foods and animal feeds hence leading to their exorbitant prices and scarcity"[20; 26]. "However, problem of high cost of feeding in aquaculture is further exacerbated due to the scare and expensive nature of some of the ingredients used in the formulation of fish feeds. In other to solve the problem of scarce and expensive feed ingredients, a number of non-conventional feedstuffs have been investigated most of which are alternative protein sources since this nutrient is considered as the most expensive nutrient"[18].

"Agro by-products are used as a fish feed ingredients which are less scares and inexpensive and they are derived from the industry due to processing of main products in large quantity. They are less fibrous, more concentrated, highly nutritious, and less expensive as compared to crop residues which are crop-waste residues mainly consist of materials remaining after harvesting and processing, such as straw, husk or stubble from barley, wheat, rice, beans, oats, rye stalks, or stovers from corn, sorghum, cotton among others"[8; 27,30,31,32,33]."Maize has been a traditional energy source in formulated feed but rising cost and accompanying scarcity is making it increasing uneconomical to include it in animal feeds. Therefore, there is need for the recruitment of other suitable ingredients that can be used as dietary energy source in the replacement of maize"[13]. The need to solve the problem of feeding in aquaculture has already been demonstrated through various researches in the utilization of agricultural waste such as Cassava peel [15; 6], Sweet potato peel [14], Poultry offal [7], water hyacinth meal [19; 29], Maize-cob meal [17], fermented sorghum [10] and fermented sorghum by-product [12] to mention a few.

Among the alternative of the local feed ingredients that can be used to feed fish are fermented agro by-products.

"Rice is one of the cereals asides the major wheat, millet, and maize. Rice is a major food source for millions of people around the world. Rice is grown mostly in tropical areas under agricultural conditions in which major cereals fail to give substantial yields"[1]. "Rice is classified with maize, sorghum, and Coix (Job's tears) in the grass sub-family *Panicoideae*"[1]. Rice is now getting popularity is it became a major source of energy and protein for millions of people in

Africa. This study investigate the effect of solid state fermentation on phytochemical composition of rice bran meal.

2. MATERIALS AND METHODS

2.1 Experimental Site

This research was conducted at the Nutrition lab of the Department of Fisheries Technology, School of Agriculture, Yobe State College of Agriculture, Science and Technology Gujba, Yobe State, Nigeria.

2.2 Source of Experimental Ingredients

Rice bran was procured from feedstuffs market Damaturu, Yobe State.

2.3 Processing and Fermentation of Millet Bran

Rice bran was collected in three different containers, ground into powder, then sieved and fermented using solid fermented procedure as described by [17]. Each sample was solidly fermented (wet at 10% moisture and keep in fermenter at ambient temperature) for 24 hours (1 day), 96 hours (4 days), and 168 hours (7 days). Afterward, the fermented samples were oven dried for one hour at 100^oC as described. The fermented samples were taken to the laboratory for nutritional, phyto-chemical analysis.

2.4 Phytochemical Screening of Fermented Samples

Two (2) grams each of the samples collected were used for quantitative phyto-chemical screening to assess Alkaloid, Cyanogens**,** Flavonoids, Glycosides, Phenols, Phytates, Oxalate, Saponin, Nitrite and Tannins on each of the treatments following the methods of [4;23].

2.5 Statistical Analysis

All data generated are subjected to descriptive statistics to determine the mean values and then subjected to analysis of variance (ANOVA) at 95% probability level where the significant differences were detected. Means values were separated using Least Significant Difference (LSD). All data were analyzed using SPSS (Statistical Package for Social Sciences) version 20.0 Statistical Package.

3. RESULTS

3.1 Phytochemical Composition of the Fermented Rice Bran Meal

The quantitative investigation of the phytochemical constituents of the fermented Rice bran at various fermentation period shows that Alkaloid, Flavonoids, Phenols, Phytate, Oxalate, Saponin and Tannin are present in all the fermented bran meals at 24 hours (1 day), 96 hours (4 days) and

168 hours (7 days) fermentation are shown in table 1. The highest content of Alkaloids in the fermented rice bran was recorded in 0 hour (0 day) fermentation with 12.61±1.04mg/kg followed by 24 hours (1 day) one with 10.24±1.52 followed by 96 hours (4 day) with 9.18±0.11 and thelowest was recorded in 168 hours (7 day) fermentation with 8.13±1.16. There is no significance (P<0.05) between 0 hour and day one. However, significance (P<0.05) was observed between day one and day seven. The highest content of Flavonoids was recorded in 168 hours (7 days) fermentation with 11.18±1.35mgRutin/kg followed by 96 hours (4 day) with 9.03±0.43mgRutin/kg, followed by 24 hours (1 day) with 7.90±1.35mgRutin/kg and the lowest was recorded in 0 hours (0 days) fermentation with 6.94±1.82mgRutin/kg. There is no significance (P<0.05) between 0 hour and day one. However, there is significance (P<0.05) between 0 hour and day seven. The highest content ofPhytate, Tannins and Saponins in rice bran were recorded in 0hours (0 day) fermentation with 6.73±1.32mg/kg, 4.60±0.13mgAT/kg and 2.98±0.54g/kg followed by 24 hours (1 day with 4.39±0.82mg/kg, 4.11±0.65mgAT/kg and 2.50±0.17g/kgfollowed by 96 hours (4 day) with 4.05±0.56mg/kg, 3.26±0.47mgAT/kg and 1.88±1.54g/kgrespectively while the lowest were recorded in 168 hours (7 days) fermentation with 2.15±0.73mg/kg, 1.52±0.24mgAT/kg and 1.43±1.17g/kg respectively.The highest phenols content was recorded in 168 hours (7 day) with 3.58±1.65gGAE/kg, followed by 96 hours (4 day) with 2.91±0.12gGAE/kg, followed by 24 hours (1 day) with 2.14±1.53gGAE/kg and the lowest was recorded in 0 hour (0 day) with 1.71±0.32gGAE/kg. The highest content of oxalate was recorded in 0 hours (0 day) fermentation with 2.78±1.25mg∞/100gand the lowest was recorded in 168 hours (7 days) fermentation with 1.82±0.13mg∞/100g. There is significant difference (P<0.05) between day one day and day seven.

Table 1: Quantitative Phytochemical Composition of Fermented Rice Bran Meal

Parameters	0Day Fermentation	1Day Fermentation	4Days Fermentation	7 Days Fermentation
Alkaloids (mg/kg)	12.61±1.04[a]	10.24±1.52[b]	9.18±0.11[c]	8.12±1.16[c]
Flavonoids (mgRutin/kg)	6.94±1.82[c]	7.90±1.35[c]	9.03±0.43[b]	11.08±1.35[a]
Phytate (mg/kg)	6.73±1.32[a]	4.39±0.82[b]	4.05±0.56[b]	2.15±0.73[c]
Tannins (mgTA/kg)	4.60±0.13[a]	4.11±0.65[a]	3.26±0.47[b]	1.52±0.24[c]
Saponins (g/kg)	2.98±0.54[a]	2.50±0.17[a]	1.88±1.54[a]	1.43±1.17[a]
Phenols (gGAE/kg)	1.71±0.32[b]	2.14±1.53[a]	2.91±0.12[a]	3.58±1.65[a]
Oxalate (mg∞/100g)	2.78±1.25[a]	2.47±1.42[a]	2.91±0.31[a]	1.82±0.13[b]

Data in the Same Row with Different Superscripts are Significantly Different (P<0.05)

4. DISCUSSION

The phytochemical investigation of the fermented Rice bran at varying fermentation periods revealed that, the ingredients contains alkaloids, flavonoids, phenols, phytate, oxalate, saponnins and tannins at varying concentrations as presented in the table 1. “These chemical compounds are synthesized in natural food and / or feedstuffs by the normal metabolism of the plant species. The biochemical are also known as ‘secondary metabolites’ in plants and they have been shown to be highly biologically active”[9]. “The compounds which reduce feed intake and nutrients utilization of plants or plant products used for feeds and they play vital roles in determining the use of plants for fish feed”[16]. More often than not, a single plant may contain two or more toxic compounds that add to the difficulties of detoxification. [9] who reported that, “alkaloids are one of the largest groups of chemical compounds synthesized by plants and generally found as salts of plant acids such as oxalic, malic, tartaric or citric acid. They are small organic molecules, common to about 15 to 20 per cent of all vascular plants, usually comprising several carbon rings with side chains of one or more carbon atoms being replaced by nitrogen. They are considered to be anti-nutrients because of their action on the nervous system, disrupting or inappropriately augmenting electrochemical transmission. Consumption of high tropane alkaloids caused rapid heartbeat, paralysis and in severe case that lead to death. Uptake of high concentration of tryptamine alkaloids lead to staggering gate and death. Indeed, the physiological effects of alkaloids on fish are very evident”. [8] who reported that “flavonoids are diphenylpropanes that constitute one of the most characteristic classes of secondary metabolites in plants Flavonoids have been shown to be potent antioxidants, capable of scavenginghydroxyl radicals, superoxide anions and lipid peroxy radicals, and have been reported as having antibacterial, anti-inflammatory, antiallergic, antimutagenic, antiviral, antineoplastic, anti-thrombotic and vasodilatory actions”[8;3]. “Another one is oxalate which is an anti-nutrient which under normal conditions is confined to separate compartments. However, when it is processed and/or digested, it comes into contact with the nutrients in the gastrointestinal tract. When released, oxalic acid binds with nutrients, rendering them inaccessible to the body. Oxalic acid binds calcium and forms calcium oxalate which is insoluble. Calcium oxalate adversely affects the absorption and utilization of calcium in the animal body”[2]. “If feed with excessive amounts of oxalic acid is consumed regularly, nutritional deficiencies are likely to occur, as well as severe irritation to the lining of the gut. Oxalic acid is of only minor significance as an anti-nutritive factor since microflora can readily metabolize soluble oxalates"[9]. "Phytate,is also a metabolites that is an inositol hexakisphosphate, containing compound that binds with minerals and inhibits mineral absorption. The cause of mineral deficiency is commonly due to its low bioavailability in the diet. The presence of phytate in fish feeds has been associated with reduced mineral absorption due to the structure of phytate which has high density of negatively charged phosphate groups which form very stable complexes with mineral ions causing non-availability for intestinal absorption"[24]. "Phytates are generally found in feed high in fibre especially in wheat bran, whole grains and legumes"[21; 28]. "Phytic acid acts as a strong chelator, forming protein and mineral-phytic acid complexes; the net result being reduced protein and mineral bioavailability"[11; 29]."Phytic acid is reported to chelate metal ions such as calcium, magnesium, zinc, copper, iron and molybdenum to form insoluble complexes that are not readily absorbed from gastrointestinal tract. Phytic acid also inhibits the action of gastrointestinal tyrosinase, trypsin, pepsin, lipase and amylase"[11]. This study is in contrast with [2] who reported decrease in tannins and phytate with increase fermentation period.

Similarly, Saponins reduce the uptake of glucose and cholesterol at the gut through intra-lumenal physicochemical interaction. Hence, it has been reported to have hypo cholesterolemic effects [22; 27]. In fish saponnins have been reported to reduce growth, feed efficiency and interferes with the absorption of dietary lipids and vitamins (A and E) [15]. It has been reported that saponins can affect animal performance and metabolism in a number of ways which include erythrocyte haemolysis, reduction of blood and liver cholesterol, depression of growth rate, enzyme inhibition and reduction in nutrient absorption [2]. Tannins may form a less digestible complex with dietary proteins and may bind and inhibit the endogenous protein such as digestive enzymes. The tannin-protein complexes are astringent and adversely affect feed intake and all plants contains phenolic compounds but their type and concentration may cause negative animal responses [12]. The concentration of condensed tannins above 4 per cent has been reported to be toxic to ruminants as they are more resistant to microbial attack and are harmful to a variety of microorganisms [24].

The results obtained in this study revealed that, the presence of alkaloids, flavonoids, phenols, phytates, oxalates, saponnins and tannins in the fermented agro by-products. The concentrations of these metabolites were moderately presence. [16] who reported that these secondary metabolites were present in varying concentrations and these variations can be explained by differences in agro-climatic conditions, age of plant, genotype, environmental conditions, post-harvest treatments, season of harvesting and maturation stage of the plants have strong influence on the phytochemical content of plants.

5. CONCLUSION

This study revealed the positive effects of solid state fermentation on phytochemicals composition of rice bran meal. The study revealed that, solid state fermentation of rice bran improved the flavonoids which serves as a flavour in the fish feed. The study also revealed that, solid state fermentation of rice bran reduces the alkaloids content of the rice bran meal which affect the nervous system thereby disrupting the electrochemical transmission in the fish.

REFERENCES

1. Adekunle, A. A. (2012). Agricultural innovation in sub-saharan Africa: experiences from multiplestakeholder approaches. *Forum for Agricultural Research in Africa*, Ghana. Pp 21-29.

2. Akande K. E., Doma, U.D., Agu, H.O. and Adamu, H.M. (2010). Major Anti-nutrients Found in Plant Protein Sources: Their Effect on Nutrition. Pakistan *Journal of Nutrition*, 9 (8): 827-832.

3. Chakraborty, S. B., Peter, H. and Csaba, H. (2013) Application of phytochemicals as growth- promoters and endocrine modulators in fish culture. *Aquaculture*, 5: 1-19.

4. Edeoga, H.O., Okwu, D.E., Mbaebie, B.O. (2005). Phytochemical constituents of some Nigeria medicinal plants. *African Journal of Biotechnology*, 4(7):685-688.

5. Falaye, C. A., Chikwunde, A. G. and Micheal, B. J. (2014) Improving Nutritional Quality of Millet (*Pennisetumamericannum*) by Solid State Fermentation and the Effects on the Growth Performance of African Catfish. *Journal of Natural Sciences Research*, 3 (6): 45-52.

6. Falaye, A.E. and Oloruntuyi, O.O. (1998) Nutritive Potential of Plantain Peel Meal and Replacement Value for Maize in Diets of African Catfish (*Clariasgariepinus*) Fingerlings *Journal of Tropical Agriculture* (Trinidad), 75 (4): 488-492.

7. Fasakin, E.A. (2008). Fish as Food yesterday, today and forever *Inaugural Lecture*, series 48, The Federal University of Technology, Akure, pp 52.

8. Gao, Y., Lu, S., Wu, M., Yao, W., Jin, Z. and Wu, X. (2019). Effect of dietary protein levels on growth, feed utilization and expression of growth related genes of juvenile giant grouper (epinepheluslanceolatus). *Aquaculture*, 504, 369-374.

9. Habtamu, F. and Negussie, R. (2014). Anti-nutritional factors in plant foods: Potential health benefits and adverse effects. *International Journal of Nutrition and Food Sciences*, 3(4): 284-289.

10. Idowu1, T.A., Ishaku, A. H., Adedeji1, H. A., Olaniyi, I.J. and Sogbesan, O.A. (2016) Effect of Varying Levels of Fermented Sorghum (*Sorghum Bicolor*) On Growth and Haematology Profiles of *ClariasGariepinus*(Burchell, 1822) Fingerlings.*Journal of Agriculture and Environment*, 12 (1): 89-96.

11. Khare, N. (2000). Phytic Acid Composition and its Effects. *Journal of Biochemistry,* 4(2): 321-336.

12. Mohammed, R. A., Jauro, I. A., Ishaku, A. H. and Usman, S. (2017) Growth Performance and Haematological Profiles of *Clariasgariepinus*(Burchell, 1822) Fed Fermented Sorghum By-product Meal. *Journal of Agriculture and Environment,* 13(2): 137-147.

13. Obe, B.W. (2014). Growth Performance and Nutrient Utilization of Catfish Hybrid (*Heterobranchusbidorsalis*X *Clariasgariepinus*) Fed Fermented Sorghum (*Sorghum bicolor*) Waste MealDiets. *International Journal of Applied Science and Technolog,* 4(3):156-160.

14. Olukunle, O. (2006). Nutritive Potential of Sweet Potato Peel Meal and Root Replacement Value for Maize in Diets of Africa Catfish (*Clariasgariepinus*) Advanced Fry. *Journal of Food Technology,* 4(4): 289- 293.

15. Olurin, K.B., Olujo, E.A.A. and Olukoya, O.A. (2006) Growth of African catfish *Clariasgariepinus*fingerlings, fed different levels of cassava. *World Journal of Zoology,* (1): 54-56.

16. Soetan K. O. and Oyewole, O. E. (2009).The need for adequate processing to reduce the anti-nutritional factors in plants used as human foods and animal feeds: A review. *African Journal of Food Science,* 3 (9): 223-232.

17. Sogbesan, O.A., K.N. Mohanta, P.K. Sahoo and P. Jayasankar (2012). *In*: Application of solid state fermentation technology in aquaculture, pp 76-83.

18. Sogbesan, A.O and Ugwumba A.A.A (2008) Nutritional Evaluation of Termite (*Macrotermes subhyalinus*) Meal as animal protein Supplements in the Diets of *Heterobranchuslongifilis*Fingerlings. *Turkish Journal of Fish and Aquatic Science,* 8:149-157.

19. Sotolu, A. O. (2008). Nutrient potential of water hyacinth as a feed supplement in sustainable aquaculture. *Obeche,*26 (1): 45-51.

20. Suprayudi, M.A. (2010). Local Raw Materials: Challenges and Expectations of Future Aquaculture (Abstract). *Proceedings of the National Symposium on Biotechnology Aquaculture* III October 7, 2010. BDP, FPIK, IPB. 31p.

21. Thava, S. and James, M. (2001). Effects of Phytic Acid on Bioavailability in Fish Feed. *Int. Journal of Food Science,* 17(1): 419-431.

22. Umaru, H. A., Adamu, R. and Nadro, M.S. (2007). Effects of Anti-Nutritional Factors in Some Wild Edible Fruits of Northern Nigeria. *African journal of biotechnology,* 16 (1): 77-77.

23. Vaghasiya, Y., Dave, R. and Chanda, L. (2011). Phytochemical analysis of some medicinal plants from western region of India. *Resource JournalMedicinalPlants,*5(5): 567-576.

24. Walter, H.L, Fanny, L., Charles, C., and Christian, R., (2002). Minerals and phytic acid interaction: is it a real problem for human nutrition. *International Journal of Food Science Techology,* (37) 727-739.

25. Woke, G. N., Aleleye-wokoma, L. P., Komi, G. W. and Bekibele, D. O. (2013) Effects of Fermented and Unfermented Mucuna Bean Seed on Growth Performance of Tilapia. *Global Journal of Pure and Applied Science,* 19: (1) 9-15.

26. Yang, X., Wan, Z., Perry, H. Lu, Q., Wang, C., Hao, J., Li, F., Xie, J., Yu, T., Cui, T., Wang, M.,Li and Ge, Q. H. (2012). Early millet use in northern China. *Proceeding of National. Academic Science USA* pp. 1–5.

27. Ying, M. (2013) “Antioxidant activities and total phenolic content in germinated and non-germinated legume extracts following alkaline-acid hydrolysis”. *Pakistan Journal of Nutrition,* 12.12: 1036.

28. Yuheng, H., Leo-mong, M. and Zues, W. (2021). Wheat Bran Fermented by Mixed Fungal Strains Improves the Digestibility of Crude Fibre in Weaned Pigs. *Journal of Animal Production,* 25-39.

29. Zhou, K., Su, L. and Yu, L. (2004). Phytochemicals and antioxidant properties in wheat bran. *Journal of Agriculture and Food Chemistry,* 52:6108-6114.

30 Kawan, Atufa, ZubairAnjum, DurreShahwar, Maratab Ali Awan, and FarazAkrim. 2015. “Effect of Aquaculture Feeding Practices on Commercial Fish Farming in Rawalpindi District, Pakistan”. Annual Research & Review in Biology 8 (2):1-10. https://doi.org/10.9734/ARRB/2015/20038.

31 Akhtar ,Nasim, Muhmmad Sultan Haider, Mamoona Kiran Zareen, Sadia Fatima, and Adeela Hassan. 2023. “Aloe Barbadensis Effect on Growth Performance and Gastrointestinal Tract of LabeoRohita”. Asian Journal of Research in Zoology 6 (4):173-85. https://doi.org/10.9734/ajriz/2023/v6i4134.

32 Yuangsoi B, Rinthong P, Charoenwattanasak S. The effect of black glutinous rice bran (Oryza sativa L.) in diets of Nile tilapia (Oreochromisniloticus).
33 Devi RR, Arumughan C. Phytochemical characterization of defatted rice bran and optimization of a process for their extraction and enrichment. Bioresource technology. 2007 Nov 1;98(16):3037-43.