J Bangladesh Agril Univ 20(1): 57–63, 2022 https://doi.org/10.5455/JBAU.130284

ISSN 1810-3030 (Print) 2408-8684 (Online)

Journal of Bangladesh Agricultural University

Journal home page: http://baures.bau.edu.bd/jbau

Research Article

Effect of Feeding Yeast (*Saccharomyces cerevisiae*) Fermented Rice Bran with Urea on the Performance of Broiler

Ruckshana Islam Liza, Jamia Ismita, Khan Md. Shaiful Islam✉, Rakhi Chowdhury, Momota Rani Debi and Naimur Rahman Joy

Department of Animal Nutrition, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

ARTICLE INFO

Article history
Received: 05 Oct 2021
Accepted: 01 Feb 2022
Published: 31 Mar 2022

Keywords
Rice bran,
Urea,
Baker's yeast,
Fermentation,
Production performance

Correspondence
Khan Md. Shaiful Islam
✉: kmsislam1@yahoo.com

OPEN ACCESS

ABSTRACT

Rice bran (RB) was fermented by baker's yeast (*Saccharomyces cerevisiae*) along with urea to know the effect on crude fiber (CF) and crude protein (CP) level as well as fed broiler to know the effects on the growth performance. A total of Ninety day-old Cobb 500 commercial broiler chicks were randomly allocated to 3 dietary groups with 3 replicate cages and 30 birds in each for 35 days feeding trial. Dietary groups were, 1- 7.0% Rice Bran (control); 2- 3.5% RB + 3.5% yeast fermented RB along with urea (YUFRB), and 3- 7.0% YUFRB. All groups were under same management practices following *ad libitum* feed and water. Live weight, feed offered and feed refusal was recorded weekly. At the end of the trial, total 9 broilers (one bird/replicate cage) were slaughtered to collect blood sample and to determine carcass characteristics. Due to fermentation of RB by yeast, significant ($p< 0.05$) increase were observed in proximate components. Crude protein has increased at 7.72%, but crude fiber has decreased at 2.3% in YUFRB. Significantly ($p< 0.05$) higher live weight (1418 g/bird), cumulative weight gain (1348 g/bird), and better (1.69) feed conversion ratio (FCR) was observed in 7.0% YUFRB group. Better performance observed in 3.5% YUFRB group ($p< 0.05$) than control. Dressed carcass weight observed more or less similar in all the dietary groups ($p> 0.05$). Cholesterol concentration was low in fermented groups ($p< 0.05$). It can be concluded that fermentation of rice bran by baker's yeast along with urea improves protein content and reduces fiber contents; its addition in broiler diet improves growth performances and lowers cholesterol level in broiler.

Introduction

Poultry producers and nutritionists are now interested to use locally available agricultural by-products to reduce feed cost by improving the nutritional value to maintain ration quality. Rice bran (RB), one of the by-products of rice milling process; is abundant in rice producing countries such as India, Bangladesh, China etc. It contains 12–22% oil, 11–17% protein, 6–14% fiber, 10–15% moisture, and 8–17% ash. It is also rich in wide variety of vitamins and minerals also (Devi *et al.,* 2021). Percentage and composition of nutrients varies according to the rice variety, pre-treatment before milling, type of milling system, hull contents and the degree of milling. It is produced 63 to 76 million tons in the world and more than 90% is sold cheaply as animal feed (Sharif *et al*., 2014). But the striking limitations of its use as poultry feed are the high fibre content, low protein and anti-nutritional factors such as phytic acid. Different techniques had been established to increase its utilization for poultry feed such as fermentation (Ullah *et al*., 2021), enzyme supplementation (Tirajoh *et al*., 2010) and inclusion of the fermented product (Kompiang *et al.,* 1995). For fermentation, yeast termed as baker's yeast (*Saccharomyces cerevisiae*) is readily available in the market and is rich in crude protein, amino acids, fatty acids, mineral elements and vitamins particularly B-vitamins (Pelicia *et al.,* 2010). Yeast (*S. cerevisiae*) has detoxification effect that reduces the phytate and other anti-nutritional contents and also improves nutrient availability (Hassan *et al.*, 2015). Gao *et al*., (2008) reported that yeast supplementation in broiler diet can improve growth parameters in broiler. Besides, yeast culture improves phosphorus utilization in growing chickens, boosts immune level resulting in a better protection against infections and increases live weight gain without affecting feed/gain ratio in broiler chicks (Panda *et al*., 2000). As yeast (S. *cerevisiae*) can degrade phytic acid, raffinose, and stachyose to below

Cite This Article
Liza, R.I., Ismita, J., Islam, K.M.S., Chowdhury, R., Debi, M.R. and Joy, N.R. 2022. Effect of Feeding Yeast (*Saccharomyces cerevisiae*) Fermented Rice Bran with Urea on the Performance of Broiler. *Journal of Bangladesh Agricultural University*, 20(1): 57–63. https://doi.org/10.5455/ JBAU.130284

detectable levels, so it may provide nutritional benefits to mono-gastric animals (Tudor *et al.,* 2013). Arzinnahar *et al.* (2021) reported that, yeast fermentation lowers fiber content and improves CP, phosphorus, Methionine and Lysine content of de-oiled rice bran. Urea is an important source of nitrogen and yeast cell growth increased with addition of urea in medium (Fadel *et al*., 2013; Abromove *et al*., 1994). Replacement of plant or animal protein by non-protein nitrogenous (NPN) sources such as urea in the broiler diet may improve growth performance of broiler. Furthermore, improvement of broiler performances also observed during feeding of additional urea fermented rice bran (Alam *et al*., 2018). So, urea was added with yeast during fermentation as a source of nitrogen for the production of single cell protein. Considering the potentialities of fermented rice bran along with urea in poultry diet, the study was designed to evaluate the changes in nutrient content and its effect on growth performance, dressing characters and some serum metabolites in broiler.

Materials and Methods

Ethical approval

Animal handling and all experimental procedures of the present study were approved and performed according to the guidelines of Animal Welfare and Experimentation Ethics Committee, Bangladesh Agricultural University, Mymensingh [AWEEC/BAU/ 2021(24)] dated (21 June, 2021).

Experimental design, diet and management of bird

The experiment was conducted with 90 day-old straight run Cobb 500 broiler chicks (initial body weight 44g) for a period of 35 days. The chicks were randomly allocated into 3 groups having 30 birds in each (10 birds/cage). Birds were reared in cages (120 cm × 76 cm) and in an open sided house with sawdust as bedding material. The dietary groups were 1- 7.0% Rice Bran (Control); 2- 3.5% Rice Bran (RB) + 3.5% Yeast and urea fermented rice bran (YUFRB); and 3- 0% Rice Bran (RB) + 7.0% YUFRB.

Commonly available feed ingredients were used to formulate the diet according to NRC (1994) showing in table 1. Birds were supplied mash feed on *ad* libitum basis and fresh clean drinking water was available at all the time. Sanitary measures were taken during the trial. All birds were vaccinated by following the manufacturer’s instruction against Newcastle Disease (ND) and Infectious Bursal Disease (Gumboro) at 4th and 11th days, respectively and booster dose for ND was done at 19th days of age through eye drop.

Table 1. Feed formulation and nutritional composition of different dietary groups

	Dietary groups		
	7.0% RB	**3.5% RB+ 3.5% YUFRB**	**7.0% YUFRB**
Ingredients	**Composition of ration(%)**		
Maize	43.85	43.85	43.85
Rice bran (RB)	7.00	3.50	0.00
Yeast and urea fermented RB	0.00	3.50	7.00
Soybean meal	37.30	37.30	37.30
Limestone	1.60	1.60	1.60
Di-calcium phosphate	1.60	1.60	1.60
Soybean oil	4.70	4.70	4.70
[1]Vitamin-mineral premix	0.20	0.20	0.20
[4]DL-Methionine	0.20	0.20	0.20
Choline chloride	0.15	0.15	0.15
Starch	3.00	3.00	3.00
Total	**100**	**100**	**100**
Components	**Nutrient composition**		
DM%	87.94	88.01	88.05
CP%	19.91	24.00	24.30
CF%	5.00	4.80	4.60
EE%	9.27	10.27	10.75
Ash%	5.68	6.31	6.76
Calculated values			
[2]ME (Kcal/Kg)	3780	3826	3851
[3]Calcium%	0.95	0.95	0.95
[3]Phosphorus%	0.43	0.43	0.43

[1] 2.0g vitamin-mineral premix: vitamin A, 13,500 IU; vitamin D_3, 1500 IU; α-DL-tocopherol acetate, 50 mg; menadione, 2mg; thiamine, 3mg; riboflavin, 5mg; cobalamine, 15 μg; folic acid, 200 μg; nicotinic acid, 60 μg; Ca-pantothenate, 30mg; Choline, 750 mg; ascorbic acid, 150 mg; Iron, 40,000 mg; Cobalt, 400 mg; Copper, 10, 000 mg; Iodine, 400 mg; Manganese, 60,000 mg; Zinc, 50,000 mg, Selenium, 150 mg; Di-Calcium Phosphate, 380 mg.

[2]Metabolizable energy (ME) was calculated using formula of Wiseman (1987), ME (kcal/kg DM) = 3951+ 54.4 EE-88.7 CF- 40.8 Ash

[3]According to NRC (1994).[1,4]Square pharmaceuticals Ltd., Bangladesh

Fermentation of RB by yeast and urea and chemical analysis

Rice bran was collected from a local rice mill. Urea and Bakery yeast (*Saccharomyces cerevisiae*) (MH consumer products Ltd., Barobkunda, Anantapur, Kunda road, Sitakunda, Chittagong, Bangladesh) were purchased from local market. Fermentation was done by using a locally designed fermenter where anaerobic condition was maintained. For fermenting 100.0 kg rice bran, 1.0 kg yeast, 60.0 kg water and 3.0 kg urea were used. Maintaining the ratio, initially required yeast and lukewarm water were mixed properly and added with half of the required RB and incorporated into the fermenter. After proper mixing, required urea and rest of the RB were added to the fermenter and kept for 24 hours at 37^0C. Conventional sun drying was followed after completion of fermentation.

After fermentation pH values of fermented rice bran with additional urea was determined at 0, 12, 24 and 48 hours interval. Proximate composition such as Dry Matter (DM), Ether Extract (EE), Crude Protein (CP), Crude Fiber (CF) and Ash were carried out according to the methods (AOAC, 2005).

Record keeping, sample collection and analysis

Initial live weight, feed intake and cumulative weight gain was recorded at weekly basis. Feed intake and feed conversion ratio (FCR) were determined using the following formula:

FI=[Feed supplied in a week(g)-feed weigh back in a week (g)]/No. of bird

FCR= FI (g)/BWG (g)

At the end of the experiment, after weighing 3 birds/ treatment were randomly selected and slaughtered, de-feathered and eviscerated to determine carcass weight and dressing percentage. The carcass yield was calculated by dividing the carcass weight by live body weight of birds multiplied by 100.

To determine serum biochemical parameters, blood sample was placed in tubes at room temperature for clotting and centrifuged at 10000 rpm for 10 minutes. The serum was then transferred into another eppendorf tube and preserved at -20°C until analysis. Cholesterol, urea, creatinine and albumin were analyzed from the blood serum by using commercial reagent kits (LINEAR Chemicals S.L.U, Spain) in Spectrophotometer (Spectronic Genesis 5, USA) at 505 nm, 570-600 nm, 490-510 nm and 630 nm wavelengths, respectively.

Statistical analysis

Initially raw data were organized by using Microsoft excel and after that data were analyzed by using SPSS version 16. All recorded and calculated variables were analyzed using one way analysis of variance (ANOVA) and Tukey's Pairwise Comparisons (1953) was followed to compare treatment means and the significance was set at ($p<0.05$).

Results and Discussion

Chemical changes of rice bran due to fermentation

The pH value of fermented RB

Changing of pH of rice bran due to fermentation is shown in Figure 1. Initial pH (6.31) of RB was decreased continuously to 5.53, 4.92 and reached 4.84 respectively at 12, 24 and 48 hours of fermentation. Fermentative action of yeast converts sugar molecules to ethanol and carbon-dioxide which decreases pH in relation to time changes and this result is in agreement with Debi *et al.*, (2019); Islam *et al.*, (2016) and Prabhu *et al.*, (2014).

Proximate value of fermented RB

In this experiment, fermentation had significant ($p< 0.05$) impact on the proximate components of RB (Table 2). The CP content of fermented RB was increased 15.74 to 23.46% in YUFRB. Similarly DM, Ash and EE were increased after fermentation of RB by yeast and urea. But, crude fiber was decreased from 12.99 (RB) to 10.68% (YUFRB). This result is consistent with Ilowefah *et al.,* (2014) who reported that fermented brown rice flour had higher amount of protein after fermentation. Besides, Alam *et al.,* (2018) found that 2.0% of urea during fermentation affects the CP content of final products. The increase of CP concentration might be due to the increased microbial population under anaerobic condition during fermentation. Yeast are single cell protein and can produce protein by their multiplication in proper environmental condition. Increase in fat content might be as a result of possible bio-conversion of carbohydrate to fat (Oboh *et al.,* 2002), and also certain fungal species are capable of building up fat during the fermentation process (Akindumila and Glatz, 1998). Fiber was reduced in fermented group which agreed with the finding of Debi *et al.,* (2019) and Jannathulla *et al.,* (2017). This might be due to brewer's yeast effectively degraded phytate phosphorus in a corn-soya based diet by activating phytase enzyme during fermentation (Shi *et al.,* 2015).

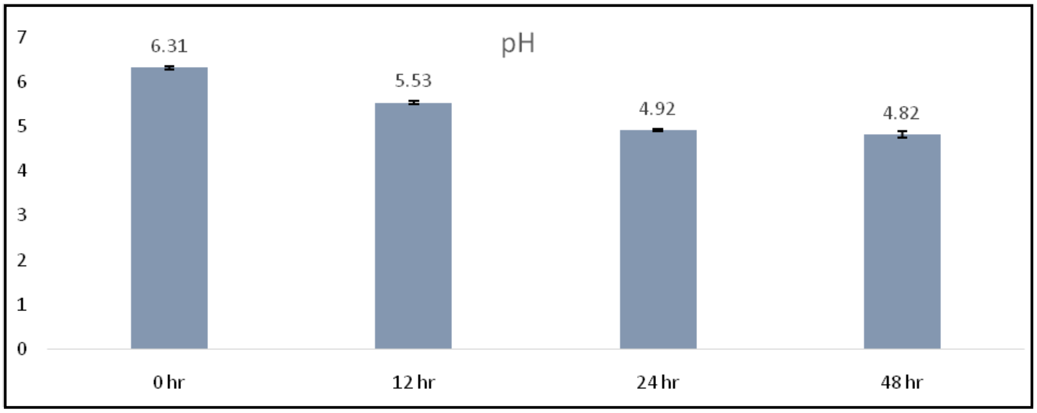

Figure 1. Changes of pH of yeast fermented rice bran with urea at different hour

Table 2. Proximate components of RB and UFRB (g/100gDM)

Components	RB	YUFRB	*p*- Value
Dry matter	88.03^{b}± 0.12	91.45^{a}± 0.4	0.011
Ash	10.01^{b}± 0.20	11.94^{a}± 0.12	0.008
Crude Protein	15.74^{b}± 0.41	23.46^{a}± 0.7	0.006
Crude Fiber	12.99^{a}± 0.12	10.68^{b}± 0.53	0.027
Ether Extract	10.01^{b}± 0.20	20.81^{a}± 0.17	0.029
Nitrogen Free Extract	42.65^{a}± 1.26	33.09^{b}± 0.99	0.014

RB-Rice bran; YUFRB- yeast fermented rice bran along with urea.
Mean±SD, ^{abc}means with different superscripts within the same row differ significantly (p<0.05).

Table 3. Growth and carcass parameters of broiler in different dietary groups

Parameters	Dietary groups			*p*-value
	Control (7.0% RB)	3.5% RB+3.5% YUFRB	7.0% YUFRB	
Live weight (g)				
Initial wt.	44.0± 0.5	44.0± 0.5	44.0± 0.5	0.531
28 days	804.2^{c}± 7.2	865.5^{b}± 8.3	911.3^{a}± 13.2	0.001
35 days	1300.2^{c}± 9.1	1366.7^{b}± 7.2	1418.7^{a}± 11.3	0.001
Cumulative Weight gain (g)				
0-28 days	744^{c}± 21.7	796^{b}± 13.3	841^{a}± 5.5	0.001
0-35 days	1240.7^{c}± 21.	1296.5^{b}± 11.2	1348^{a}±5.8	0.001
Feed Intake (g)				
0-28 days	1304.0^{b}± 21.9	1338.8^{b}± 18.8	1381.35^{c}± 5.0	0.004
0-35 days	2254.4± 18.7	2247.9± 12.8	2279.36± 7.9	0.070
Feed conversion ratio (FCR)				
0-28 days	1.75^{a}± 0.03	1.68^{b}± 0.02	1.64^{b}± 0.01	0.002
0-35 days	1.81^{a}± 0.02	1.73^{b}± 0.02	1.69^{c}± 0.01	0.001
Dressing characters				
Dressed wt.	1043±176	1060±134	1142±121	0.691
Dressing%	80.23±1	77.56±3	80.49±1	0.647

RB-Rice bran; YUFRB- yeast fermented rice bran along with urea
Mean±SD, ^{abc}Means with different superscripts within the same row differ significantly (p<0.05).

Growth and carcass parameters

Growth and carcass parameters for different dietary groups are shown in Table 3. Among the dietary groups 7.0% YUFRB expressed positive effect (p<0.05) for all the parameters throughout the study period. After the end of the trial the 7.0% YUFRB group obtained 1418.7 g live weight which was higher than control and combined group, respectively 1300 and 1366 g. Relatively higher cumulative weight gain (p<0.05) was achieved by the two fermented dietary groups. Maximum cumulative weight gain was observed in 7% YUFRB group (1348 g). Intake was always higher for broilers of fermented dietary groups than control from 0 to 28 days (p< 0.05), but, there was no significant effect ($p>0.05$) of feed intake from 0 to 35 days. Positive ($p<0.05$) effect was found in case of FCR. From the first week until the end of experiment lower FCR were recorded in 7.0% YUFRB group (1.69) compared to control (1.81). Inclusion of fermented feed in diet gives better live weight and weight gain than unfermented feed. The result is consistent with the findings of other researchers (Kang *et al*., 2015; Ahmad *et al.,* 2017) who reported that fermented rice bran improves weight gain. Moreover, fermentation process of rice bran caused a change of nutrient content and increased digestibility of crude protein, calcium and phosphorus (Wizna *et al*., 2012). Some authors reported that diets supplemented with yeast (S. *cerevisiae*) cell-wall components, can improve the growth performance of chickens due to decrease in colonization of *Escherichia coli* and increased *Lactobacilli* in the gut of chicken (Zhang *et al.,* 2005). Ahmad *et al.* (2017) reported that the inclusion of fermented feed in the diet might be beneficial in terms of nutrient digestibility, feed intake and growth performance in broilers. Increased feed intake was occurred as fermentation produces palatable feed with preferred flavors and water soluble vitamins such as B_1, B_2, and B_{12} and minerals (Kubad *et al*., 1997). On the other hand, decreasing CF content in the diets increased feed consumption of broiler chickens (Jimenez-Moreno *et al.,* 2010). Melegy *et al*. (2011) reported that, FRB supplemented group showed a significantly ($p<0.05$) better FCR compared to control group (Ahmad *et al*., 2017, Alam *et al.,* 2018). Besides, Supriyati *et al*., (2015) stated that 15% inclusion of FRB in the diet provided the best feed conversion ratio (FCR) values. Fermentation produces enzymes, mainly amylase and protease, breaks down complex carbohydrates and proteins to be readily available as a source of energy. According to Haldar *et al*. (2011), the use of yeast cell in broiler diets improved feed conversion ratio as it reduces the pathogenic bacteria load in the intestine. As a result, more efficient use of nutrients from fermented rice bran lowers the feed conversion ratio. So, yeast fermented rice bran with addition of urea is better utilized because of favorable chemical changes of RB through fermentation.

Non-significant differences ($p>0.05$) were found among the dietary groups in case of dressing characters. The dressing percentage (75%) was highest in control and 7.0% YUFRB group. Alam *et al.*, (2018) revealed similar result that weight of dressed carcass was more or less similar in all the groups ($p<0.05$). Therefore, dressing percentage was not different among the groups when fermented rice bran supplied to broilers. On the other hand, Zhang *et al.,* (2005) reported that the inclusion of S. *cerevisiae* in broiler rations affect significantly all carcass parameters including dressing percentage that contradicts this result.

Table 4. Serum metabolites of birds receiving different dietary groups

Parameters	Dietary groups			*p*-values
	Control (7.0% RB)	3.5%RB+3.5% YUFRB	7.0% UFRB	
Creatinine (mg/dl)	0.09±0.01	0.10±0.05	0.12±0.02	0.578
Albumin (g/dl)	0.9±0.2	0.4±0.1	0.4±0.3	0.287
Urea (mg/dl)	5.5±1.3	9.6±2.2	7.2±1.4	0.275
Cholesterol (mg/dl)	$100.7^{a}±1.0$	$92.0^{b}±0.3$	$73.7^{c}±2.6$	0.001

RB-Rice bran; YUFRB- yeast fermented rice bran along with urea
Mean±SD, ^{abc}Means with different superscripts within the same row differ significantly ($p<0.05$).

Serum metabolites

Serum metabolites are presented in Table 4. Except cholesterol ($p<0.05$), all the serum metabolites did not show significant changes for all dietary groups ($p>0.05$). Blood cholesterol was higher (100.7 mg/dl) in control and lower (73.7 mg/dl) in 7.0% YUFRB group. Serum urea and creatinine level were increased than control group numerically. Blood parameters are good indicators of physiological, pathological and nutritional status of an animal and changes in hematological parameters have the potential of being used to elucidate the impact of nutritional factors and additives supplied in diet on any living creature. In this experiment, total cholesterol was reduced in fermented group that was also revealed by Alam *et al.* (2018). The reduction of cholesterol by increasing the levels of RB in the diets could relate to the high content of fatty acids in RB, which increases insoluble complexes and soap compounds and leads to lower cholesterol absorption. Another study showed that S. *cerevisiae* was able to remove cholesterol in animal guts (Psomas *et al.,* 2003). Bidura *et al.* (2012) reported that diet supplemented with rice bran fermented by *Saccharomyces spp.* decreased total cholesterol concentrations in male Bali ducklings. The urea values determined in this trial was consistent with those found by Batina *et al.* (2005).

Conclusion

When *Saccharomyces cerevisiae* was used with addition of urea for fermenting rice bran, it decreases the crude fiber and increases ether extract and crude protein. Thus fermentation reduces the limitation of rice bran and improves nutritive value. Its use in the broiler ration improves the production performances and reduces cholesterol content in blood serum. So, it can be concluded that 7.0% yeast fermented rice bran added urea (YUFRB) may be an available and potential source of feed ingredient instead of raw rice bran to fulfill the demand of feed in poultry industry.

Acknowledgement

This piece of research work has financed by Bangladesh Bureau of Educational Information & Statistics (BANBEIS), Ministry of Education, and Government of the People's Republic of Bangladesh.

Conflict of interest

None.

References

Ahmad, A., Anjum, A.A., Masood, R. 2017. Effect of fermented rice bran on growth performance and bio-availability of phosphorus in broiler chicken. *Indian Journal of Animal Research*, 55: 362-365. https://doi.org/10.18805/ijar.v0iOF.8002

Akindumila, F., Glatz, B.A. 1998. Growth and oil production of *Apiotrichum curvatum* in tomato juice. *Journal of Food Protection*, 61: 1515–1517.

Alam, M.A., Islam, K. M. S., Khan, M. S. R., Dickhöfer, U., Grashorn, M. A. 2018. Growth performance and blood profile of broiler fed fermented Rice bran by rumen inoculums and supplementation of urea and molasses. *Journal of Agricultural Engineering and Food Technology*, 5: 67-70.

AOAC. 2005. Official Methods of Analysis of Association of Official Analytical Chemists. 18th Edition, Washington, DC.

Azrinnahar M., Islam, N., Shuvo, A.A.S., Kabir, A.K.M.A., Islam, K.M.S. 2021. Effect of feeding fermented (*Saccharomyces cerevisiae*) de-oiled rice bran in broiler growth and bone mineralization. *Journal of the Saudi Society of Agricultural Sciences*, https://doi.org/10.1016/j.jssas.2021.05.006

Batina, P.N., Lopes, S.T.A., Santurio, J.N., Souza, C., Martins, D.B. 2005. Efeitos da adiçãode montmorilonita sódica na dietas obre o perfil bioquímico de frangos de corteintoxicados com aflatoxina. *Ciência Rural*, 35: 826-831. https://doi.org/10.1590/S0103-8482005000400012

Bidura, I.G.N.G., Mahardika., I.G., Suyadnya, I.P., Partama, I.B.G., Oka, I.G.L., Aryani, I.A.S. 2012. The implementation of Saccharomyces spp.n-2 isolate culture (isolation from traditional yeast culture) for improving feed quality and performance of male Bali ducking. *Agricultural Science Research Journal,* 2: 486-492. https://doi.org/10.3923/pjn.2019.1075.1083

Debi, M.R., Wichert, B.A., Liesegang, A. 2019. Method development to reduce the fiber content of wheat bran and rice bran through anaerobic fermentation with rumen liquor. *Asian-Australian Journal of Animal Science*, 32: 395-404. https://doi.org/10.5713/ajas.18.0446

Devi, R., Veliveli, V. L., S Devi S. 2021. Nutritional composition of rice bran and its potentials in the development of nutraceuticals rich products. *Journal of Pharmacognosy and Phytochemistry,* 10(2): 470-473.

Fadel, M., Keera, A.A., Mouafi, F.E., Kahil, T. 2013. High level ethanol from sugar cane molasses by a new thermotolerant *Saccharomyces cerevisiae* strain in industrial scale. *Biotechnology Research International*, https://doi.org/10.1155/2013/253286

Gao, J., Zhang, H.J., Yu, S.H., Wu, S.G., Yoon, I., Quigley, j., Gao, Y.P., Qi, G.H. 2008. Effects of yeast culture in broiler diets on performance and immune-modulatory functions. *Poultry Science*, 87(7):1377–1384. https://doi.org/10.3382/ps.2007-00418

Haldar, S., Ghosh, T.K., Toshiwati, B.M.R. 2011. Effects of yeast (*Saccharomyces cerevisiae*) and yeast protein concentrate on production performance of broiler chickens exposed to heat stress and challenged with *Salmonella enteridis*. *Animal Feed Science and Technology*, 168: 61–71. https://doi.org/10.1016/j.anifeedsci.2011.03.007

Hassan, M.S., Soltan, M.A., Abdel-Moez, A.M. 2015. Nutritive value of soybean meal after solid state fermentation with *Saccharomyces cerevisiae* for Nile tilapia, *Oreochromis niloticus*. *Animal Feed Science and Technology*, 20(1): 89-98. https://doi.org/10.1016/j.anifeedsci.2015.01.007

Ilowefah, M., Chinma, C., Bakar, J., Ghazali, H.M., Muhammad, K., Makeri, M. 2014. Fermented brown rice flour as functional food ingredient. *Foods*, 3: 149-159. https://doi.org/10.3390/foods3010149

Islam,KMS, Lv RL, Dang RH, Sabgah MRFE, Sugino T, Obitsu T. 2016. Anaerobic fermentation of rice bran using rumen innoculate for desirable chemical changes as, feed for livestock. *2nd International Conference on Livestock Nutrition*, July 21-22, 2016, Bresbane, Australia. pp.06.

Jannathulla, R., Dayal, J.S., Vasanthakumar, D., Ambasankar, K., Muralidhar, M. 2017. Effect of fermentation methods on amino acids, fiber fractions and anti- nutritional factors in different plant protein sources and essential amino acid index for Penaeus vannamei Boone. *Indian Journal of Fisheries*, 64: 40-47. https://doi.org/10.2077/ijf.2017.64.2.60341-07

Jiménez-Moreno, E., González-Alvarado, J.M., González-Sánchez, D., Lázaro, R., Mateos, G.G. 2010. Effects of type and particle size of dietary fiber on growth performance and digestive traits of broilers from 1 to 21 days of age. *Poultry Science*, 892: 197-212. https://doi.org/10.3382/ps.2010-00771

Kang, H.K., Kim, J.H., Kim, C.H. 2015. Effect of dietary supplementation with fermented rice bran on the growth performance, blood parameters and intestinal microflora of broiler chickens. *European Poultry Science*, 79: 1-11. https://doi.org/10.1186/s40781-016-0092-6

Kompiang, I.P., Sinurat, A.P., Purwadaria, T., Darma, J., Supriyati. 1995. Cassapro in broiler rations: Interaction with rice bran. *Indonesian Journal of Animal and Veterinary Science*,1: 86-88. http://dx.doi.org/10.14334/jitv.v1i2.15

Kubad, R.C., Singh, K., Saxena, K., Eriksson, K. 1997. Microorganism as alternative source protein. *Nutrition Reviews*, 55: 65–75. https://doi.org/10.1111/j.1753-4887.1997.tb01599.x

Melegyet, T., Khaled, N.F., El-Bana, R., Abdellatif, H. 2011. Effect of dietary supplementation of Bacillus subtilisPB6 (Clostat™) on performance, immunity, gut health and carcass traits in broilers. *Journal of Animal Science*, 7: 891-898.

NRC. 1994. Nutrient Requirements of Poultry. 9th rev. ed. National Academy Press, Washington, DC.

Oboh, G., Akindahunsi, A.A., Oshodi, A.A. 2002. Nutrient and anti-nutrient content of *Aspergillus niger f*ermented cassava products (flour and gari). *Journal of Food Composition and Analysis*, 15: 617-622. https://doi.org/10.1177/026010600701800405

Panda, A.K., Reddy, M.R., Rao, S.R., Raju, M.V.L.N., Praharaj, N.K. 2000: Growth, carcass characteristics, immune-competence and response to *Escherichia coli* of broilers fed diets with various levels of probiotic. *Archiv für Geflügel kunde*, 64 152-156.

Pelícia, V.C., Sartori, J.R., Zavarize, K.C., Pezzato, A.C., Stradiotti, A.C., Araujo, P.C., Madeira, L.A. 2010. Effect of nucleotides on broiler performance and carcass yield. *Revista Brasileira de Ciência Avícola*, 12: 31-34. https://doi.org/10.1590/S1516-635X2010000100004

Prabhu, A.A., Mrudula, C.M., Rajesh, J. 2014. Effect of yeast fermentation on nutraceutical and antioxidant properties of rice bran. *Journal of Agricultural and Food Chemistry*, 4: 59-65. http://eprints.manipal.edu/id/eprint/139536

Psomas, E.I., Fletouris, D.J., Litopoulou-Tzanetaki, E., Tzanetakis, N. 2003. Assimilation of cholesterol by yeast strains isolated from infant feces and feta cheese. *Journal of Dairy Science*, 86: 3416–3422. https://doi.org/10.3168/jds.S0022-0302(03)73945-9

Sharif, M.K., Butt, M.S., Anjum, F.M., Khan, S.H. 2014. Rice Bran: A Novel Functional Ingredient. *Critical Reviews in Food Science and Nutrition*, 54: 807-816. https://doi.org/10.1080/10408398.2011.608586

Shi, C., He, J., Yu, J., Yu, B., Huang, Z., Mao, X., Zheng, P., Chen, P. 2015. Solid state fermentation of rapeseed cake with *Aspergillus niger* for degrading glucosinolates and upgrading nutritional value. *Journal of Animal Science and Biotechnology*, 6: 13-19. https://doi.org/10.1186/s40104-015-0015-2

Supriyati, Haryati, T., Susanti, T., Susana, I.W.R. 2015. Nutritional value of rice bran fermented by *Bacillus amyloliquefaciens* and humic substances and its utilization as a feed ingredient for broiler chickens. *Asian-Australian Journal of Animal Science*, 28: 231-238. https://doi.org/10.5713/ajas.14.0039

Tirahzoh, S., Piliang, W.G., Ketaren, P.P. 2010. The supplementation of fiber degrading enzymes and phytase in poultry diet on the performance of broiler chickens. *Indonesian Journal of Animal and Veterinary Science*, 15: 40–46.

Tudor, K.W., Jones, M.A., Hughes, S.R., Holt, J.P., Wiegand, B.R. 2013. Effect of fermentation with *Saccharomyces cerevisiae* strain PJ69-4 on the phytic acid, raffinose, and stachyose contents of soybean meal. *The Professional Animal Scientist*, 29: 529-534. https://doi.org/10.15232/S1080-7446(15)30274-6

Ullah, H., Islam, K.M.S., Shuvo, A.A.S., Rahman, M.M., Alam, M.S., Dickhöfer U., Grashorn, M.A. 2021. Effects of feeding rumen liquor fermented rice bran on performance of broiler. *Animal Nutrition and Feed Technology*, 21:177-186**.** https://doi.10.5958/0974-181X.2021.00014.7

Wiseman, J. 1987. Feeding of Non-Ruminant Livestock. *Butterworths and Co. Ltd.*, London, UK

Wizna, H.A., Rizal, Y., Djulardi, A., Muis, H. 2012. The effect of supplementation of micro nutrient on nutrient rice bran which fermented by *Bacillus amyloliquefaciens*. *Pakistan Journal of Nutrition*, 11: 439-443. http://dx.doi.org/10.3923/pjn.2012.439.443

Zhang, A.W., Lee, B.D., Lee, S.K., Lee, K.W., An, G.H, Song, K.B, Lee, C.H. 2005. Effects of yeast (*Saccharomyces cerevisiae*) cell components on growth performance, meat quality, and ileal mucosa development of broiler chicks. *Poultry Science*,84:1015-102.https://doi.org/10.1093/ps/84.7.1015