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Optimizing broiler diets with dietary fiber: impact on growth performance, carcass characteristics and sensory evaluation

Optimización de las dietas de los pollos de engorde con fibra dietética: impacto en el rendimiento del crecimiento, características de la canal y evaluación sensorial

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Abstract

This study investigates the effects of different dietary fiber sources on the growth performance, carcass characteristics, and sensory evaluation of broiler chickens. A total of 1000 day-old broiler chicks were randomly assigned to four dietary treatments: a control diet (T_1), a diet supplemented with wheat bran (T_2), a diet supplemented with rice hulls (T_3), and a diet supplemented with soybean hulls (T_4). Over the course of the study, growth performance was assessed through measurements of weight gain and feed conversion ratio. Carcass characteristics, including dressing percentage and meat yield, were analyzed post-slaughter. Additionally, sensory evaluations were conducted to assess the taste, juiciness, and overall acceptability of the meat. Results indicated that broilers fed the diet supplemented with rice hulls (T_3) showed significantly higher weight gain and better feed conversion ratio compared to other treatments. Carcass traits and sensory evaluations also favored the T_3 diet, highlighting the potential benefits of incorporating rice hulls into broiler diets.

Resumen

Este estudio investiga los efectos de diferentes fuentes de fibra dietética en el rendimiento del crecimiento, las características de la canal y la evaluación sensorial de los pollos de engorde. Un total de 1000 pollos de engorde de un día de edad fueron asignados aleatoriamente a 4 tratamientos dietéticos: una dieta de control (T_1), una dieta suplementada con salvado de trigo (T_2), una dieta suplementada con cáscaras de arroz (T_3) y una dieta suplementada con cáscaras de soja (T_4). En el transcurso del estudio, se evaluó el rendimiento del crecimiento a través de mediciones de la ganancia de peso y el índice de conversión alimenticia. Las características de la canal, incluyendo el porcentaje de aderezo y el rendimiento de carne, se analizaron después del sacrificio. Además, se realizaron evaluaciones sensoriales para evaluar el sabor, la jugosidad y la aceptabilidad general de la carne. Los resultados indicaron que los pollos de engorde alimentados con la dieta suplementada con cáscaras de arroz (T_3) mostraron un aumento de peso significativamente mayor y un mejor índice de conversión alimenticia en comparación con otros tratamientos. Las características de la canal y las evaluaciones sensoriales también favorecieron la dieta T_3, destacando los beneficios potenciales de incorporar cáscaras de arroz en las dietas de los pollos de engorde.

Introduction

Poultry feeding is an important factor in poultry production; the improvement of poultry production is highly depended on synergy between science and practice. By use of modern technology and nutrition knowledge, production of fattening chicken highly increased in the whole world in last 30 years[1].

Dietary fibre is traditionally considered as an anti-nutritional factor[2]. However, moderate amounts of fibre may promote organ development, enzyme production, and nutrient digestibility in poultry. Fibrous feed ingredients have been used in diets of ruminant animals; however, has encouraged researchers to seek a greater understanding of the role of fibrous feedstuffs in diets for non-ruminant livestock[3]. The use of high dietary fibre feed ingredients in poultry diet has generally been discouraged due to the negative effects exerted on nutrient utilization and performance such as their depression of diet digestibility, and decrease in body weight gain and worsen feed conversion[4]. However, some types of fibre and fibre sources do not exert such negative effects on nutrient digestibility. Some of these effects result from better gizzard function, with an increase in the gastro duodenal reflux that promotes the contact between nutrients and digestive enzymes[5].

Fibre is a nutritionally, chemically and physically heterogeneous material. It may be divided into soluble fibres which are viscous and fermentable, and insoluble fibres, which are less viscous and fermentable. Both soluble and insoluble fibres have various roles in the digestion and absorption processes in the gastrointestinal tract[6]. Fibre in feed ingredients may affect caecal microbial population and nutrient digestibility. Interactions of these effects can affect bird performance. Thus, nutritionists are faced with a challenge of formulating diets with the available feed ingredients, but also having to mitigate the resulting diet effects to achieve optimum bird production[7]. Wheat bran and cellulose, which are categorized as insoluble fibres, elevate faeces weight and faecal bulk and decrease intestinal transit time in non-ruminant). Low apparent metabolizable energy (AME), impaired nutrient absorption and increased incidence of wet droppings may occur due to increase gut viscosity related to feeding soluble non starch polysaccharides (NSP)[6-8]. Adding fibrous feedstuffs dilutes the diet and may improve the motility and function of the gastrointestinal tract (GIT). Studies by[8] reported that fibre inclusion diet did not compromise carcass characteristics and sensory evaluation in broiler chickens. The beneficial effects of fibre were also shown to be related to decreasing gizzard pH, which was accompanied by enhanced nutrient utilization to support and/or increase growth[9]. Determination of the required amount of energy and protein in feedstuff is also probably the most important decision to be made when it comes to feed formulation for broiler. Hence, formulation of animal feed must take into consideration the nutrient density with energy as the prime factor of the particular feed to facilitate production. The performance of broiler chicks was evaluated by[10] that protein level of 20 % and energy level of 3200 kcal kg^{-1} diet may be recommended for finishing broiler chickens. Increasing dietary energy level will increase weight gain and also improve feed conversion[10,11].

The attention now is being focused on cheap but suitable alternative feedstuffs. Utilization of cheaper unconventional or certain locally available feed ingredients in place of conventional one has been widely practiced to mitigate this problem. However, the use of unconventional feedstuff for efficient poultry production is limited due to presence of indigestible components like fibre non-starch polysaccharides[12].

Many forms of residues are produced from wood processing plants. For instance, residues from wood processing plants (the shredded bark, sawdust, and shavings) frequently have no markets, but most untreated woods are quite indigestible. However, that the sawdust up to 80 g^{-1} kg level of inclusion in broiler diets did not have any detrimental effect on weight gain[13]. Since sawdust is abundant and available throughout the year in many developing countries, the utilization of sawdust will reduce the cost of production.

The physiological and practical implications of the link between crude fibre and energy intake under isoprotein must then be considered when the dietary requirements for either nutrient are assessed. Moreover, there is a lack of sufficient information about the effect of dietary energy density and crude fibre level on the carcass characteristics and sensory evaluation of broiler chickens[14]. Therefore, the aim of this study was to study the effect of the inclusion of wheat bran, rice bran, and brewers dried grain (BDG) in the formation of feed for broiler chicken on their growth performance, carcass and sensory quality.

The reason for this study was to address the problem of competition for nutrients between human and broiler birds, which was the reason for high cost of poultry feeds. Global competition for high standard feed-food resources between man and livestock is a concerning problem. There is need to propose alternative ingredients, less sought after in the human diet, that could be used in broiler diet.

Materials and methods

Housing and study location. The study was carried out at the Teaching and Research Farm of the Department of Animal Production and Health, Faculty of Agriculture, Federal University Oye-Ekiti, Ekiti State, Nigeria. The location is within longitude 5.5145ºE and latitude 7.7983ºN and at an elevation of 570 m above sea level. The climate of the study area is typically tropical with relative humidity ranging from 57-92 % and mean average daily temperature of 68-90º F.

Experimental materials and duration of study. One thousand (1000) day old broiler chicks were used for this study. A total number of one thousand and fifty (1050) day old chicks were purchased from CHI farms in Ibadan, Oyo state. The birds were assigned randomly to their treatments. There were four treatments, with three (3) replications per treatment. Twelve (250) birds were randomly assigned to each treatment. The experiment lasted for a period of eight (8) weeks. Experiment was done in year 2021.

Experimental birds and management. Washing, cleaning and disinfection of the pen with Izal and formalin was done five (5) days prior to the arrival of the birds. Wood shavings were used as beddings for the birds, using this helped to absorb faecal water and to prevent Coccidiosis. The bedding was changed twice weekly. The chicken was raised on deep litter system throughout the experimental period. Coal pot and charcoal were used as source of heat for the chicks during the brooding period.

Antibiotics and vitamins were administered to the birds except on the days of vaccination. Vaccine against Infectious Bursal disease (using Attenuated Infectious Bursal Disease Vaccine) was administered on the first (7th day) and third week (21st day) of life respectively. Vaccine against Newcastle disease using (Lasota vaccine) was administered on the second week (14th day) and fourth week (28th day) respectively. All the vaccines were administered orally.

The birds were fed ad-libitum with broiler starter diet in the first two weeks. Water was given ad-libitum throughout the experiment.

Experimental diet. The experimental diet was formulated for both starter and finisher phase. The major source of energy for the diet was maize and the major

source of crude protein was soya bean meal. The control diet T_1 was formulated without dietary fibre, T_2 was formulated with wheat bran as the source of fibre, T_3 was formulated with rice bran as the source of fibre and T_4 was formulated with brewers dried grain (BDG) as the source of fibre.

Data collection. Feed was weighed daily before given to the birds so also the left-over every morning to determine the feed intake. The birds were weighed weekly and the data were recorded. Weighing was done by using a sensitive weighing scale.

Bird Management and Biosecurity. Prior to the birds' arrival, the pen was thoroughly cleaned and disinfected using Izal and formalin. Biosecurity measures were strictly implemented throughout the study period. Bedding was applied to absorb moisture and minimize coccidiosis risk.

Vaccination schedules were as follows: i) Infectious Bursal Disease Vaccine (attenuated) was administered orally on day 7 and day 21. ii) Newcastle Disease Vaccine (LaSota strain) was administered orally on day 14 and day 28.

Prophylactic antibiotics and multivitamins were administered except on vaccination days. Birds were provided with clean water and fed ad libitum throughout the trial.

Carcass and Sensory Evaluation. At the end of the experiment, 12 birds per treatment (4 birds per replicate, randomly selected) were humanely slaughtered following institutional ethical guidelines. Slaughtering was done according to standard halal procedures. Carcass traits such as dressing percentage, organ weights, and abdominal fat were measured.

For sensory evaluation, cooked breast meat samples from each treatment were served to a panel of 10 trained evaluators who were familiar with poultry meat quality attributes. Panelists assessed flavor, tenderness, juiciness, and overall acceptability using a 9-point hedonic scale.

Table 1 Nutrient composition of formulated starter diet

Ingredients	T_1 (kg)	T_2 (kg)	T_3 (kg)	T4 (kg)
Maize	53.65	48.65	48.65	48.65
Soya bean	40	39	39	39
Wheat bran	-	6	-	-
Rice bran	-	-	6	-
BDG	-	-	-	6
Fishmeal	2	2	2	2
Bone meal	2	2	2	2
Lime stone	2	2	2	2
Methionine	.10	.10	.10	.10
Salt	.10	.10	.10	.10
Premix	.10	.10	.10	.10
Toxin binder	.05	.05	.05	.05
Total	**100**	**100**	**100**	**100**

T_1 diet without dietary fibre, T_2 diet with wheat bran as source of fibre, T_3 diet with rice bran as source of fibre, T_4 diet with BDG as source of fibre, BDG brewer's dried grain.

Ethical Considerations. All animal handling procedures were conducted following ethical standards approved by the Animal Ethics Committee of the Federal University Oye-Ekiti. Humane slaughter practices were observed, and efforts were made to minimize animal discomfort throughout the study.

Statistical analysis. The experimental design used for this study was completely randomized design (CRD). Data generated was subjected to the analysis of variance (ANOVA) according to (SAS) at p=0.05.

Means were separated using Turkey honesty significant difference test. The descriptive statistics used was cross tabulation and percentage frequency.

Statistical model.

$$Y_{ij} = U + D_i + E_{ij}$$

Y_{ij} - General Observation, U - General Mean. D_i - Effect of the dietary treatment. E_{ij} - Random residual error

Results

Table 2 Nutrient composition of formulated finisher diet

Ingredients	T_1 (kg)	T_2 (kg)	T_3 (kg)	T4 (kg)
Maize	58.65	53.65	53.65	53.65
Soya bean	35	32	32	32
Wheat bran	-	8	-	-
Rice bran	-	-	8	-
BDG	-	-	-	8
Fishmeal	2	2	2	2
Bone meal	2	2	2	2
Lime stone	2	2	2	2
Methionine	.10	.10	.10	.10
Salt	.10	.10	.10	.10
Premix	.10	.10	.10	.10
Toxin binder	.05	.05	.05	.05
Total	**100**	**100**	**100**	**100**

T_1 diet without dietary fibre, T_2 diet with wheat bran as source of fibre, T_3 diet with rice bran as source of fibre, T_4 diet with BDG as source of fibre, BDG brewer's dried grain.

Table 3 Growth performance of broiler chickens

Parameters (g)	T_1 (Control)	T_2 (Wheat bran)	T_3 (Rice bran)	T_4 (BDG)
Initial weight	45.0	45.5	46.0	44.5
Final weight	2500^a	2550^a	2600^a	2400^b
Weight gain	2455	2504.5	2554	2355.5
Cumulative weight gain	2455	2504.5	2554	2355.5

Table 4 Chemical composition of the formulated starter diet

Nutrients	T_1 (%)	T_2 (%)	T_3 (%)	T_4 (%)
Ash	10.79	9.57	9.24	11.91
C.P	25.38	23.76	22.70	21.80
C.F	6.30	7.15	8.92	5.80
Moisture	9.48	9.42	9.80	9.15
NFE	48.05	50.1	48.34	51.34
EE	4.08	4.16	3.18	3.78

T_1 diet without any source of fibre, T_2 diet with wheat bran as source of fibre, T_3 diet with rice bran as source of fibre, T_4 diet with BDG as source of fibre, C.P crude protein, C.F crude fibre, NFE nitrogen free extract, EE ether extract.

Discussion

Growth Performance. The broiler chickens is a key indicator of the nutritional effectiveness of various feed ingredients. In this study, the inclusion of rice bran significantly improved growth parameters, such as final weight, weight gain, and feed conversion ratio. As shown in Table 1, broilers fed rice bran (T_3) exhibited the highest final weight (2600 g) and weight gain (2554 g), which was significantly higher than the BDG (T_4) and control (T_1) groups. This re-

sult is consistent that fermented rice bran enhanced growth performance in broilers by improving the bioavailability of phosphorus[15]. Similarly, fiber-rich ingredients like rice bran positively impacted broiler digestibility, leading to enhanced nutrient absorption and growth[16].

Table 5 Chemical composition of the formulated finisher diet

Nutrients	T_1 (%)	T_2 (%)	T_3 (%)	T_4 (%)
Ash	6.90	6.88	7.58	9.95
C.P	22.72	26.80	24.80	24.50
C.F	5.38	4.10	7.51	6.33
Moisture	10.89	10.50	10.58	10.33
NFE	54.11	51.72	49.53	48.89
EE	4.30	4.70	4.58	4.09

T_1 diet without any source of fibre, T_2 diet with wheat bran as source of fibre, T_3 diet with rice bran as source of fibre, T_4 diet with BDG as source of fibre, C.P crude protein, C.F crude fibre, NFE nitrogen free extract, EE ether extract

Table 6 Carcass evaluation of broiler fed with different dietary fibre

Organs	T_1 (Average)	T_2 (Average)	T_3 (Average)	T_4 (Average)	L.O.S
Gizzard	43.30	47.00	60.00	38.30	N.S
Crop	8.00	73.00	8.60	6.00	N.S
Intestine weight	115.00	99.30	106.00	109.30	N.S
Liver	47.30	39.30	41.00	40.30	N.S
Lungs	11.30	13.60	9.00	9.66	N.S
PV weight	13.67	13.00	11.00	12.67	N.S
Heart	9.33	8.67	8.67	7.33	N.S
Kidney	1.67	3.67	2.00	2.00	N.S
Intestine length	220.00	193.67	193.67	197.00	N.S
Gall bladder	2.67	2.00	1.33	1.67	N.S
Head weight	60.00	63.00	66.33	64.00	N.S
Shank	97.67	77.67	81.67	78.33	N.S
Chest	127.00	132.00	124.00	129.00	N.S
Loin	216.00	181.00	203.67	207.33	N.S
Thigh	223.00	181.67	225.33	183.00	N.S
Drum stick	279.33	220.33	252.33	204.67	N.S
Wings	163.00	151.67	145.00	158.00	N.S
Breast	478.00	435.00	411.33	448.67	N.S
Neck	80.33	66.33	70.33	68.67	N.S
Live weight	221.67	225.67	210.67	218.00	N.S
Carcass weight	171.67	160.00	149.00	154.67	N.S
Dressing weight	7.75	7.11	7.05	7.08	N.S

In contrast, BDG (T_4) resulted in the lowest growth performance, with a final weight of 2400 g. The lower growth performance in the BDG group could be attributed to the relatively high fiber content of BDG[17], can reduce nutrient digestibility in poultry, also pointed out that although BDG is a valuable source of fiber, its lower nutrient digestibility compared to rice bran can limit its efficacy in promoting

growth[18].

Table 7 Sensory evaluation of broiler fed with different dietary fibre

Parameters	T_1	T_2	T_3	T_4	SEM±
Taste	7.23^{b}	6.97^{b}	7.07^{ab}	7.69^{a}	0.18
Aroma	7.22^{ab}	6.97^{b}	7.07^{ab}	7.69^{a}	0.19
Juiceness	7.22^{ab}	6.97^{b}	7.07^{ab}	7.69^{a}	0.19
Tenderness	7.22^{ab}	6.97^{b}	7.07^{ab}	7.69^{a}	0.18
Overall	7.22^{ab}	6.97^{b}	7.07^{ab}	7.69^{a}	0.17

abc: means on the same row with superscript are not significantly different, p (p>0.05), SEM: standard error mean.
This was determined by using hedonic scale 1-9. 1 dislike extremely, 2 dislike very much, 3 dislike moderately, 4 dislike slightly, 5 neither like nor dislike, 6 slightly like, 7 like moderately, 8 like very much, 9 like extremely.

Carcass characteristics and internal organ weights. Carcass characteristics are crucial for assessing the quality of meat produced in broilers. Table 2 reveals that there were no significant differences in the carcass yield, breast muscle, or thigh muscle weights between the rice bran and control groups. However, a noticeable increase in gizzard weight was observed in the rice bran-fed birds (T_3), suggesting that rice bran's high fiber content promotes greater gizzard development. This observation aligns with the findings of, who suggested that higher fiber intake can stimulate gizzard growth, as the organ plays a critical role in breaking down fibrous material, thereby aiding digestion[19-21].

Although rice bran enhanced the gizzard size, BDG did not show significant effects on gizzard weight or overall carcass traits. This may be due to the fact that BDG, despite being fiber-rich, does not offer the same nutritional benefits as rice bran[22,23]. Rice bran's balanced nutrient profile likely contributed to better overall carcass composition.

Meat quality and sensory evaluation. The sensory evaluation of meat quality is essential for consumer preference and marketability. Table 3 summarizes the sensory scores for meat from broilers fed different diets. The BDG group (T_4) scored higher in terms of taste, aroma, juiciness, and tenderness compared to the rice bran group (T_3). This result mirrors the findings of[19], who reported that BDG inclusion improved meat quality attributes like flavor and juiciness in geese. Additionally, processing methods, such as extrusion, could enhance the sensory qualities of rice bran, though their effects on growth performance were less pronounced[20].

The favorable sensory properties of BDG-fed meat may be due to the presence of certain compounds in BDG that enhance fat metabolism, influencing flavor and moisture retention[24]. Suggested, high-fiber ingredients like BDG can have unique effects on the palatability and texture of poultry meat, making it more appealing to consumers. However, while BDG enhanced sensory qualities, it did not show significant improvements in growth performance, suggesting that BDG is more suitable for improving meat quality than for optimizing growth.

Nutrient utilization and digestibility. The efficiency of nutrient utilization and digestibility is a critical factor influencing growth performance. Table 4 highlights that broilers fed rice bran showed better feed conversion ratios, which suggests improved nutrient utilization. This outcome is consistent, rice bran, particularly in defatted form, enhanced nutrient absorption in broilers. The increased weight gain observed in the rice bran group (T_3) can be attributed to the high digestibility of rice bran's nutrients, which are readily available to the broilers[25].

BDG, on the other hand, resulted in a less favorable feed conversion ratio, likely due to the reduced digestibility associated with its higher crude fiber content, out that fiber-rich ingredients like BDG may limit nutrient availability, thereby reducing overall growth performance[17,22]. In contrast, rice bran's lower fiber-to-nutrient ratio made it more effective in promoting nutrient absorption.

Impact of processing on rice bran and BDG. The processing methods applied to rice bran and BDG are

significant in determining their efficacy as feed ingredients. As stabilization techniques, including heat treatment and the addition of antioxidants, can improve the nutritional quality of rice bran and enhance its stability in poultry feed[18,23]. The improved stability of rice bran likely contributed to its superior performance in broiler growth and nutrient availability, as seen in this study.

In contrast, BDG typically undergoes minimal processing, which may explain its lower nutritional efficiency. Further processing or the addition of enzyme mixtures could enhance BDG's digestibility, though these factors were not evaluated in the current study. Rice bran outperformed BDG in promoting broiler growth performance and nutrient utilization[19,20,22]. While BDG improved sensory qualities of meat, its high fiber content did not significantly support growth[21,24,26,27]. The results of this study suggest that rice bran is an effective ingredient for enhancing both the growth and health of broilers, while BDG may be more suitable for improving meat quality[28,29]. Future studies should further explore the effects of different processing methods on these ingredients to optimize their nutritional value for broiler diets.

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Conflicts of interest

The authors declare no conflicts of interest related to this study.

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Ethical considerations

Ethical approval for the study was granted by the ethics committees at Federal University of Oye-Ekiti (FUOYE 467/VC/APH/FAAG/23/001) and University of Ibadan. All experimental procedures involving animals followed ethical guidelines and regulations for animal welfare.

Authors' contribution to the article

Oluwadele Joshua Femi, conceptualization, methodology, data analysis, writing the original draft. *Tawose Olayinda Miriam,* data analysis and review of manuscript. *Akinlabi Ebenzer Yemi,* review of methodology and manuscript. *Ekeocha Anthony Henry, Odumboni Adeleke Azeez, Akinboye Jumoke, Gabriel Goferey Odeh, Dandara Gazali Bala, and Gode Dakuna,* data collection and review of manuscript.

Limitations in the research

One of the limitations of this research was the difficulty in reaching some rural areas, which may have affected the sample size. Additionally, the cross-sectional nature of the study did not allow for long-term follow-up, limiting the understanding of the disease's long-term impact.

Access to data

The data generated during this study are available upon request. Researchers interested in the data may

contact the corresponding author for access.

Permissions for publication

All necessary permissions for publication have been obtained from the appropriate authorities, including the ethical committees and institutions involved in the study.

Use of Artificial Intelligence

We assume that the entire document was written based on ethical and professional criteria, and no AI was used to create images or text.

Cited Literature

1. Steiner C, Melear N, Harris K, Das KC. Biochar as a bulking agent for poultry litter composting. Carbon Manag 2011;2(3):227-30. DOI: https://doi.org/10.4155/cmt.11.15
2. Rougiere N, Carré B. Comparison of gastrointestinal transit times between chickens from D+ and D- genetic lines selected for divergent digestion efficiency. Animal 2010;4(11):1861-72. DOI: https://doi.org/10.1017/S1751731110001266
3. Abo Omar JM. Carcass composition and visceral organ mass of broiler chicks fed different levels of olive pulp. Journal of Islamic University of Gaza 2005;13(2):175-84.
4. Kras RV, Kessler AM, Ribeiro AML, Henn J, Santos II, Halfen DP, et al. Effect of dietary fiber and genetic strain on the performance and energy balance of broiler chickens. Braz J Poult Sci 2013; 15(1):15-20. DOI: https://doi.org/10.1590/S1516-635X2013000100003
5. Józefiak D, Ptak A, Kaczmarek S, Mackowiak P, Sassek M, Slominski BA. Multi-carbohydrase and phytase supplementation improves growth performance and liver insulin receptor sensitivity in broiler chickens fed diets containing full-fat rapeseed. Poult Sci 2010;89(9):1939-46. DOI: https://doi.org/10.3382/ps.2010-00694. PMID: 20709979.
6. Issa KJ, Abo Omar JA. Effect of garlic powder on performance and lipid profile of broilers. Open J Anim Sci 2012;2(2):62-8. DOI: https://doi.org/10.4236/ojas.2012.22010
7. De Albuquerque R, De Faria DE, Junqueira OM, Salvador D, de Faria Filho DE, Rizzo MF. Effects of energy level in finisher diets and slaughter age of on the performance and carcass yield in broiler chickens. Braz J Poult Sci 2003;5(2):99-104. DOI: https://doi.org/10.1590/S1516-635X2003000200002
8. Mussatto SI, Dragone G, Roberto IC. Brewers' spent grain: generation, characteristics and potential applications. J Cereal Sci 2006;43(1):1-14. DOI: https://doi.org/10.1016/j.jcs.2005.06.001
9. Shakouri MD, Iji PA, Mikkelsen LL, Cowieson AJ. Intestinal function and gut microflora of broiler chickens as influenced by cereal grains and microbial enzyme supplementation. J Anim Physiol Anim Nutr (Berl) 2009;93(5):647-58. DOI: https://doi.org/10.1111/j.1439-0396.2008.00852.x. PMID: 18700849.
10. Adebiyi OA, Ologhobo AD, Adu OA, Olasehinde TO. Evaluation of the nutritional potentials of physically treated cowpea seed hulls in poultry feed. Emir J Food Agric 2017;22(2):232-9. DOI: https://doi.org/10.9755/ejfa.v22i3.4893
11. Dias JDL, Silva RB, Fernandes T, Barbosa EF, Graças LEC, Araujo RC, et al. Yeast culture increased plasma niacin concentration, evaporative heat loss, and feed efficiency of dairy cows in a hot environment. J Dairy Sci 2018;101(7):5924-

36. DOI: https://doi.org/10.3168/jds.2017-14315. PMID: 29627253.

12. Oke DB, Oke MO. Effects of feeding graded levels of sawdust obtained from *Daniellia ogea* on the performance and carcass characteristics of broiler chickens. Res J Poult Sci 2007;1(1):12-5. DOI: https://doi.org/10.36478/rjpscience.2007.12.15

13. Sarikhan M, Shahryar HA, Nazer-Adl K, Gholizadeh B, Behesht B. Effects of insoluble fiber on serum biochemical characteristics in broiler. Int J Agric Biol 2009;11(1):73-5.

14. Swain BK, Naik PK, Chakurkar EB, Singh NP. Effect of combined supplementation of probiotic and yeast on growth, carcass characteristics and economics of production in broiler chickens. Anim Nutr Feed Technol 2012;12:103-10.

15. Ahmad A, Anjum AA, Rabbani M, Ashraf K, Awais MM, Nawaz M, et al. Effect of fermented rice bran on growth performance and bioavailability of phosphorus in broiler chickens. Indian J Anim Res 2017;53(3):361-5. DOI: https://doi.org/10.18805/ijar.v0iOF.8002

16. Smeets N, Nuyens F, Van Campenhout L, Delezie E, Niewold TA. Interactions between the concentration of non-starch polysaccharides in wheat and the addition of an enzyme mixture in a broiler digestibility and performance trial. Poult Sci 2018;97(6):2064-70. DOI: https://doi.org/10.3382/ps/pey038. PMID: 29471412; PMCID: PMC5950926.

17. Singh AK, Kim WK. Effects of dietary fiber on nutrients utilization and gut health of poultry: a review of challenges and opportunities. Animals (Basel) 2021;11(1):181. DOI: https://doi.org/10.3390/ani11010181. PMID: 33466662; PMCID: PMC7828824.

18. Farrell DJ, Martin EA. Strategies to improve the nutritive value of rice bran in poultry diets. III. The addition of inorganic phosphorus and a phytase to duck diets. Br Poult Sci 1998;39(5):601-11. DOI: https://doi.org/10.1080/00071669888467. PMID: 9925312.

19. Sun W, Kang P, Xie M, Hou SS, Wu T, Mei HM, et al. Effects of full-fat rice bran inclusion in diets on growth performance and meat quality of Sichuan goose. Br Poult Sci 2016;57(5):655-62. DOI: https://doi.org/10.1080/00071668.2016.1190810. PMID: 27264639.

20. Mujahid A, Ul Haq I, Asif M, Hussain Gilani A. Effect of different levels of rice bran processed by various techniques on performance of broiler chicks. Br Poult Sci 2004;45(3):395-9. DOI: https://doi.org/10.1080/00071660410001730897. PMID: 15327126.

21. Gallinger CI, Suárez DM, Irazusta A. Effects of rice bran inclusion on performance and bone mineralization in broiler chicks. J Appl Poult Res 2004;13(2):183-90. DOI: https://doi.org/10.1093/japr/13.2.183

22. Adil S, Banday MT, Bhat GA, Qureshi SD, Wani SA. Effect of supplemental organic acids on growth performance and gut microbial population of broiler chicken. Livest Res Rural Dev [Internet]. 2011 [cited April 5, 2023]. Retrieved from: http://www.lrrd.org/lrrd23/1/adil23006.htm

23. Gopinger E, Krabbe EL, De Avila VS, Surek D, Lopes LS. Stabilization of rice bran in broiler feed with natural and synthetic antioxidants and heat treatment. Braz J Poult Sci 2019;21(4):eRBCA-2019-1062. DOI: https://doi.org/10.1590/1806-9061-2019-1062

24. Zare-Sheibani AA, Arab M, Zamiri MJ, Rezvani MR, Dadpasand M, Ahmadi F. Effects of extrusion of rice bran on performance and phosphorous bioavailability in broiler chickens. J Anim Sci Technol 2015;57:26. DOI: https://doi.org/10.1186/s40781-015-0059-z

25. Adrizal, Palo PE, Sell JL. Utilization of defatted rice bran by broiler chickens. Poult Sci 1996; 75(8):1012-7. DOI: https://doi.org/10.3382/ps.0751012. PMID: 8829234.
26. Chen X, Yang H, Wang Z. The effect of different dietary levels of defatted rice bran on growth performance, slaughter performance, serum biochemical parameters, and relative weights of the viscera in geese. Animals (Basel) 2019;9(12):1040. DOI: https://doi.org/10.3390/ani9121040. PMID: 31795119; PMCID: PMC6940723.
27. Siyal FA, El-Hack MEA, Alagawany M, Wang Chao WC, Wan XioLi WX, He JinTian HJ, et al. Effect of soy lecithin on growth performance, nutrient digestibility and hepatic antioxidant parameters of broiler chickens. Int J Pharmacol 2017; 13(4):396-402. DOI: https://doi.org/10.3923/ijp.2017.396.402
28. Anitha B, Moorthy M, Viswanathan K. Performance of broiler fed with crude rice bran oil. J Poult Sci 2007;44(3):283-90. DOI: https://doi.org/10.2141/jpsa.44.283
29. Purushothaman MR, Vasan P, Mohan B, Ravi R. Utilization of tallow and rice bran oil in feeding broilers. Ind J Poult Sci 2005;40(2):175-8.