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RESEARCH

Effect of Storage Time of Dietary Rice Bran on Growth Performance and Meat Quality of Broiler Chicken

B.A.D.A. Samarasinghe[1ǂ], S.M.R. Samarakoon[2ǂ], P. Weththasinghe[1, 2], and B.C. Jayawardana[1, 2*]

[1]*Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka*
[2]*Post Graduate Institute of Agriculture, University of Peradeniya, Sri Lanka*

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Jayawardana B.C.
https://orcid.org/0000-0002-8563-2378

ABSTRACT

This study evaluated the impact of rice bran storage duration on broiler chicken growth performance and meat quality. Ninety-six male Cobb 500 chicks were randomly assigned to four groups, each receiving one of four isonitrogenous and isoenergetic diets: a control corn-soy diet or diets containing rice bran stored for less than 24 hours, 1 week, or 30 days. Growth performance was monitored, and after 30 days, carcass traits, digestive organ measurements, and meat quality parameters were assessed. Diets containing rice bran stored for 1 week and 30 days exhibited elevated Thiobarbituric acid reactive substances (TBARS) values, indicating increased lipid oxidation. Notably, broilers fed rice bran stored for 30 days showed reduced ($P<0.05$) final body weight, weight gain, and feed intake, along with a higher feed conversion ratio compared to the control group. This diet also led to increased relative weights and lengths of digestive tract organs and higher meat TBARS values. However, other meat quality characteristics, including cooking loss, drip loss, water holding capacity, pH, and color, remained unaffected by the dietary treatments. In conclusion, incorporating rice bran stored for 30 days into broiler diets can negatively influence growth performance and meat TBARS values.

*Corresponding author - baranaj@agri.pdn.ac.lk

ǂThese authors have contributed equally to this work

INTRODUCTION

Over the past few decades, chicken meat has consistently gained popularity globally due to its affordability and health benefits (Pinto da Rosa *et al.,* 2021). Since feed accounts for a substantial share of broiler production costs (Vissers *et al.,* 2019), optimizing nutrient balance and utilizing cost-effective ingredients is crucial for performance (Beski *et al.,* 2015).

Rice bran, a by-product of the rice milling process, is a valuable and economical source of energy, protein, and essential fatty acids for poultry (Hossain *et al.,* 2012; Ijaz *et al.,* 2021). However, the supply chain from rice mills to feed mills is often delayed due to the intermediate operations and attempts of the traders to secure higher prices for rice bran by creating an artificial shortage. These delays result in extended storage periods, which facilitate lipid oxidation (Rashid *et al.,* 2022). This is a significant concern for the industry, as consuming diets with rancid ingredients can adversely affect animal health and productivity (Pasha *et al.,* 2008).

The rapid hydrolysis of glycerides into free fatty acids is the primary driver of oxidation in rice bran, occurring within the first few days or weeks after milling (Rashid *et al.,* 2022). This process degrades nutritional value and produces off-flavors and odors that can reduce feed palatability (Ramezanzadeh *et al.,* 1999; Khalique *et al.,* 2003). Despite its widespread use, there is limited information on how the duration of rice bran storage impacts its quality and the subsequent effects on broiler performance. Therefore, this study was conducted to analyze the effects of rice bran storage time on broiler growth performance and meat quality.

METHODOLOGY

The experimental protocol received approval from the Ethical Review Committee of the Faculty of Agriculture at the University of Peradeniya, Sri Lanka, as indicated by the Ethical Clearance Certificate Number ECC/2023/R/072. The study strictly followed the Guidelines for Ethics Review of Research Proposals Involving Animals in Sri Lanka, established by the Forum of Ethics Review Committees of Sri Lanka in 2009 (Forum for Ethics Review Committees of Sri Lanka 2009).

Experimental diets

Four iso-energetic and iso-nitrogenous experimental diets were formulated to meet Cobb 500 broiler requirements (2018) for all essential amino acids and other nutrients. The experimental diets comprised a corn-soy-based control diet without the inclusion of rice bran (CD), three diets containing rice bran stored for <24 hours (RB1), 1 week (RB2) or 30 days (RB3). The storage conditions include: temperature of 29 °C and relative humidity of 75–85%, with rice bran packaged in polybags and stored without prior stabilization. The inclusion levels of rice bran in starter and finisher diets were 10% and 15%, respectively. The diets were produced in mash form at the CIC Feeds (Pvt) Ltd, Sri Lanka. The ingredient and proximate compositions of starter and finisher diets are shown in Table 1 and Table 2, respectively. Although minor variations in analysed crude protein and energy values were observed among the experimental diets, these differences were within biologically acceptable limits and are not expected to have influenced the overall outcomes. The oxidative status of the rice bran was monitored by the analysis of diets.

Table 1: Ingredient composition of the experimental diets (g/kg)

Ingredient	Starter		Finisher	
	Control diet	Rice bran containing diets	Control diet	Rice bran containing diets
Corn	604	519	646	534
Soybean meal	305	295	288	271
Vegetable oil	7.6	8.2	15	21
Rice bran	0	103	0	150
Meat and bone meal	36	35	20	20
Calcium carbonate	9.9	4.1	7.9	7.4
Dicalcium phosphate	13	13	5.5	0.0
Salt	1.0	1.0	2.8	2.7
Sodium bicarbonate	2.7	2.6	1.8	1.5
Mineral premix	1.0	1.0		
Vitamin premix	1.0	1.0	1.5	1.5
DL-Methionine	3.9	3.9	2.9	3.0
L-Lysine HCl 98.5%	5.1	5.0	2.7	2.8
L-Threonine 98%	2.3	2.4	1.1	1.3
L-Valine 96.5%	1.7	1.7		
L-Arginine 98%	1.7	1.5		
AlLzyme SSF	0.2	0.2		
Clopidol	0.1	0.1		
Elitox	1.0	1.0		
Mycocurb	1.0	1.0		
Activo	0.1	0.1		
Choline chloride 50%	1.2	1.0	1.4	1.4

SSF: Solid State Fermentation

Table 2: Analyzed nutrient composition of experimental diets.

	CD	RB1	RB2	RB3
Starter				
Dry matter (%)	94	95	95	94
Ash (% DM)	9.2	8.6	7.6	10.1
Crude protein (% DM)	27	27	26	27
Crude fat (% DM)	4.0	4.7	4.9	5.0
Crude fibre (% DM)	4.1	6.5	6.1	6.8
Energy (kcal/kg)	3890	3967	3970	3933
Finisher				
Dry matter (%)	98	96	96	97
Ash (% DM)	8.8	9.2	9.7	10.0
Crude protein (% DM)	22	23	23	22
Crude fat (% DM)	6.64	6.67	6.68	6.69
Crude fibre (% DM)	3.5	3.5	3.5	3.5
Energy (kcal/kg)	4044	4058	4086	4092

DM: Dry matter. CD: Control diet (Corn-soy-based control diet without rice bran). RB1: Diet containing rice bran stored for <24 hours, RB2: Diet containing rice bran stored for 1 week, RB3: Diet containing rice bran stored for 30 days.

Broiler study, rearing facilities, and sampling

The broiler study was conducted at the Poultry Research Unit, Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka. A total of 96, one-day-old, male, “Cobb 500” birds were purchased from Ravi Breeder Farm (Pvt) Ltd, Ganemulla Road, Ja-Ela, Sri Lanka. The birds were distributed into 16 cages (n=6/cage, paper-bedded floor-1400 cm^2/bird) with 4 cages per group. The mean air temperature of cages was approximately 29°C till 7 days of age, 30 °C from 8 to 14 days of age, and then decreased gradually to a constant temperature of 28 °C, which was held until the end of the trial. The lighting schedule was set to 24 hours of light for the first three days and, 22 hours of light and 2 hours of darkness for the rest of the period. The birds were given Vita stress (1 g/L) and Avifloxin 10 (Enrofloxacin) (0.5 ml/L) with lukewarm water during the first three days. All the birds were vaccinated for the infectious bursal disease at 7 days of age.

Quadruplicate cages of broilers were fed one of the four experimental diets for 35 days on a twice-a-day schedule. Broilers were fed starter diets from day one to day 22, followed by a transition period of three days during which the diet was changed gradually to the finisher diet. The finisher diet was provided to the birds from day 23 to 35. Water was available ad-libitum throughout the study. Feed consumption of the birds was measured daily and body weights were measured weekly. No mortalities of birds were observed during the experimental period, and no birds were excluded from the study. At the end of the feeding period, the birds were starved for 12 hours before slaughtering, and body weights were measured after 12 hours of feed withdrawal. Among these birds, 32 birds (n=8/group, 2 birds per cage) were used to measure the weights of various organs, including the carcass, breast, liver, gizzard, spleen, bursa, pro-ventriculus, cecum, duodenum, jejunum, and ileum, and the lengths of the duodenum, jejunum, and ileum. The whole breast was removed from each carcass and stored at 4 °C until the meat quality analyses.

Chemical analysis

The proximate composition (dry matter, ash, crude protein, crude fat, crude fibre and energy) of diets was measured according to Association of official analytical chemists (AOAC) International 1995. The dry matter content was determined by oven-drying samples at 105 °C until a constant weight was reached. Ash content was determined by combustion at 600 °C. The nitrogen (N) content of diets was estimated by the Kjeldahl method. The crude protein (CP) content was determined as N×6.25. Samples were extracted with Soxhlet extraction and gravimetric method was used to determine the crude fat content. Samples were extracted with a digestion apparatus and the crude fibre content was determined using gravimetric method. A bomb calorie meter (IKA C7000, India) was used to analyze the gross energy value. The 2-thiobarbituric acid reactive substance (TBARS) as mg of malonaldehyde (MDA)/kg was employed to measure the lipid oxidation of diets and meat samples according to AOAC International, 1995. Briefly, 2 g of meat/feed sample was placed in a centrifuge tube to which 5 mL of a 10% (w/v) solution of trichloroacetic acid (TCA) was added and vortexed (Vortex-GENIE, No 11716, Scintific Industries, Inc., USA) at high speed for two min. 5 mL of 0.02M aqueous solution of 2-thiobarbituric acid (TBA) was then added to centrifuge tube and vortexed for 30 sec. The samples were centrifuged (CF 1502, Himac, Hitachi, Japan) at 3000xg for 10 min and the supernatants were filtered through a Whatman No.3 filter paper. Filtrates were heated in a boiling water bath (W 270, Memmert, GmbH Co., Germany) for 45 min, cooled to room temperature in ice, and the absorbance of the resulting pigment was measured at 532 nm using a spectrophotometer (Type 5104, No 453, WPA Linton, Cambridge, UK). TBARS values were calculated by multiplying the absorbance reading by a factor of 7.0, which was obtained from a standard line prepared with 1, 1, 3, 3-tetramethoxy methane as a precursor of malonaldehyde.

Meat quality parameters

The pH of breast meat was measured 48 hours postmortem with a portable pH-meter (pH 211, Hannah Instruments, Mauritius) (AOAC International 1995). Drip loss was measured according to Sarsenbek *et al.* (2013). In brief, the left Pectoralis major muscle was excised, weighed, placed in a polyethene bag and stored at 4 °C. The muscle was removed from the bag, wiped, and weighed to determine the drip loss, which was expressed as a percentage of the initial muscle weight. The colour was measured with a portable Chroma colour meter (CS-10, CHN Spec Technology, China). The chroma colour meter was calibrated for its original value with a standard white plate. Measured colour values were reported according to the Commission international de l'Eclairage (CIE) system values of lightness (L*), redness/greenness (a*), and yellowness/blueness (b*) (Bianchi and Fletcher, 2002). Water Holding Capacity (WHC) was measured using method described in AOAC (1995). The cooking loss was calculated based on the weight of the muscle before and after cooking according to Choo *et al.* (2014).

CALCULATION

Body weight gain was calculated as (Final body weight -Initial body weight). Feed intake was calculated as (Feed given - Uneaten feed). Feed conversion ratio (FCR) was calculated as (Feed intake/ Body weight gain). Carcass yield was calculated as (Dressed carcass weight/ Live weight) ×100. Relative weights of organs were calculated as (Weight of organ/ Live weight) ×100. The relative weight of the breast was calculated as the (Weight of breast meat/Carcass weight) ×100. Relative lengths of organs were calculated as (Length of organ/ Live weight) ×100. The WHC was calculated as (Weight of sample after centrifugation - Weight of sample after drying)/ (Initial weight of the sample) ×100. Drip loss was calculated as (Weight of sample before thawing - Weight of sample after thawing)/ (Initial weight of the sample) ×100. Cooking loss was calculated as (Weight of raw meat - Weight of cooked meat)/ (Initial weight of the sample) ×100.

Statistical analysis

The cage was the experimental unit for performance parameters, while the individual bird was the experimental unit for carcass traits and meat quality measurements. The data were analyzed using one-way ANOVA, followed by Tukey's multiple comparison test to compare the means. Differences at P<0.05 were regarded as significant. The analyses were performed using IBM SPSS Statistics 26 software.

RESULTS

TBARS values of diets

The rice bran-incorporated broiler starter diets showed higher (P<0.05) TBARS values than the control diet in the first week, but no differences were observed among the three rice bran-included diets. In the fifth week, the broiler finisher diets containing rice bran stored for 1 week or 30 days had higher (P<0.05) TBARS values compared to the control diet, while the TRARS value of the diet containing rice bran stored for 30 days was also higher (P<0.05) than the diet with rice bran stored for <24 hours (Table 3).

Growth performance

The growth performance of broiler chicken fed experimental diets is in Table 4. The body weight gain, feed intake, and FCR of birds showed no differences among the experimental groups during the early experimental period (1−21 days). However, the birds fed the diet with rice bran stored for 30 days had the lowest (P<0.05) feed intake and final body in week 4, and lowest body weight at the end of week 5. Overall, the birds fed diets containing rice bran stored for 30 days showed lower (P<0.05) feed intake, final body weight, and weight gain compared to the birds fed control diet and two diets containing rice bran stored for <24 hours and 1 week. Feeding rice bran stored for 30 days also resulted in higher (P<0.05) FCR than the control diet.

Table 3: Thiobarbituric Acid Reactive Substances (TBARS.) values of broiler starter and finisher diets (mg equivalents/kg)

	CD	RB1	RB2	RB3	SEM	*P* value
1st week[1]	17.2^{b}	22.2^{a}	21.9^{a}	20.2^{a}	0.76	<0.01
3rd week[1]	24.5	24.3	21.5	23.2	0.55	0.15
5th week[2]	14.4^{c}	15.5^{bc}	17.4^{ab}	18.2^{a}	0.58	<0.01

Values are expressed as means (n=3). Values in the same row with different superscripts are significantly different at *P* < 0.05. SEM: Standard error mean. CD: Control diet (Corn-soy-based control diet without rice bran). RB1: Diet containing rice bran stored for <24 hours, RB2: Diet containing rice bran stored for 1 week, RB3: Diet containing rice bran stored for 30 days. [1] Broiler starter diet. [2] Broiler finisher diet.

Table 4: Growth performance of broiler chicken fed experimental diets

	CD	**RB1**	**RB2**	**RB3**	**SEM**	***P* value**
Week 1						
Initial body weight (g)	46.8	47.1	46.7	47.0	0.11	0.78
Final Body weight (g)	169.5	153.9	162.9	157.5	2.59	0.16
Weight gain (g/bird)	122.6	106.8	116.1	110.5	2.58	0.14
Feed intake (g/bird)	127.8	130.4	130.2	131.9	0.71	0.26
FCR (g/g^{-1})	1.0	1.2	1.1	1.2	0.03	0.13
Week 2						
Final Body weight (g)	473.1^{a}	441.3^{b}	475.9^{a}	434.5^{b}	6.76	0.03
Weight gain (g/bird)	303.6	287.3	313.0	277.0	5.75	0.10
Feed intake (g/bird)	336.7	389.1	385.3	373.8	9.26	0.17
FCR (g/g^{-1})	1.1	1.3	1.2	1.3	0.04	0.11
Week 3						
Final Body weight (g)	852.5	812.1	842.7	735.3	19.80	0.14
Weight gain (g/bird)	379.3	370.8	366.7	300.8	14.98	0.23
Feed intake (g/bird)	599.3	651.7	646.6	594.5	19.15	0.64
FCR (g/g^{-1})	1.6	1.8	1.7	2.0	0.12	0.72
Week 4						
Final Body weight (g)	1372.2^{a}	1352.1^{a}	1282.1^{a}	1031.0^{b}	42.64	<0.01
Weight gain (g/bird)	519.7	539.9	440.2	295.6	36.34	0.05
Feed intake (g/bird)	746.8^{a}	860.8^{a}	830.1^{a}	669.2^{b}	24.10	<0.01
FCR (g/g^{-1})	1.6	1.6	1.8	2.6	0.20	0.18
Week 5						
Final Body weight (g)	1805.3^{a}	1795.8^{a}	1689.2^{a}	1305.9^{b}	64.24	<0.01
Weight gain (g/bird)	433.0	443.7	406.2	274.8	27.17	0.08
Feed intake (g/bird)	765.3	879.0	837.6	691.9	28.08	0.07
FCR (g/g^{-1})	1.8	2.0	2.1	2.8	0.16	0.15
Overall						
Initial body weight (g)	46.9	47.1	46.8	47.0	0.11	0.78
Final Body weight (g)	1805.4^{a}	1795.9^{a}	1689.2^{a}	1305.9^{b}	64.24	<0.01
Weight gain (g/bird)	1758.5^{a}	1748.7^{a}	1642.4^{a}	1258.9^{b}	64.23	<0.01
Feed intake (g/bird)	2576.2^{a}	2911.3^{a}	2830.1^{a}	2461.5^{b}	61.01	<0.01
FCR (g/g^{-1})	1.5^{a}	1.7^{ab}	1.7^{ab}	2.0^{b}	0.06	0.03

Values are expressed as means (cage=n=4). Values in the same row with different superscripts are significantly different at $P < 0.05$. SEM: Standard error mean. CD: Control diet (Corn-soy-based control diet without rice bran). RB1: Diet containing rice bran stored for <24 hours, RB2: Diet containing rice bran stored for 1 week, RB3: Diet containing rice bran stored for 30 days.

Relative organ weights & lengths

The responses of relative weights and lengths of internal organs to the experimental diets are shown in Table 5. The birds fed rice bran stored for 30 days had higher (P<0.05) relative weights of the duodenum, jejunum, and ileum and relative length of the duodenum compared to birds fed the control diet and rice bran stored for <24 hours. Carcass and breast muscle yield and relative weights and lengths of other organs had no differences among the experimental groups (Table 5).

Table 5: Carcass yield, breast muscle yield and relative organ weights and lengths (%) of broiler chicken fed experimental diets for 35 days

	CD	RB1	RB2	RB3	SEM	*P* value
Carcass yield[1]	65.8	63.5	66.2	68.1	1.30	0.64
Breast muscle yield[2]	43.5	42.5	42.5	42.4	0.41	0.83
Liver weight[1]	1.9	1.7	1.8	1.8	0.04	0.41
Gizzard weight[1]	1.1	1.2	1.1	1.3	0.04	0.39
Spleen weight[1]	0.06^{b}	0.09^{ab}	0.10^{b}	0.08^{ab}	<0.01	<0.01
Bursa weight[1]	0.2	0.2	0.2	0.2	0.01	0.89
Pro-ventriculus weight[1]	0.3	0.3	0.4	0.4	0.02	0.05
Caecum weight[1]	0.2	0.3	0.3	0.3	0.01	0.10
Duodenum weight[1]	0.4^{b}	0.4^{b}	0.4^{ab}	0.5^{a}	0.02	0.03
Jejunum weight[1]	0.8^{b}	0.8^{b}	1.0^{ab}	1.1^{a}	0.03	<0.01
Ileum weight[1]	0.8^{b}	0.7^{b}	0.8^{ab}	0.9^{a}	0.03	0.03
Duodenum length (cm/g)[1]	1.4^{b}	1.3^{b}	1.6^{ab}	2.0^{a}	0.08	<0.01
Jejunum length (cm/g)[1]	3.6^{b}	3.2^{b}	4.0^{ab}	4.7^{a}	0.18	<0.01
Ileum length (cm/g)[1]	4.1^{b}	3.2^{b}	4.1^{ab}	4.9^{a}	0.18	<0.01

Values are expressed as means (cage=n=4). Values in the same row with different superscripts are significantly different at $P < 0.05$. SEM: Standard error mean. CD: Control diet (Corn-soy-based control diet without rice bran). RB1: Diet containing rice bran stored for <24 hours, RB2: Diet containing rice bran stored for 1 week, RB3: Diet containing rice bran stored for 30 days. [1]Calculated as a percentage of live weight. [2]Calculated as a percentage of carcass weight.

Meat quality

The experimental diets had no impact on the meat quality parameters and colour values, except on the TBARS values which was highest in the birds fed rice bran stored for 30 days, followed by the birds fed rice bran stored for 1 week and <24 hours (Table 6 and 7).

Table 6: Meat quality parameters of broiler chicken fed experimental diets for 35 days

Meat quality parameter	CD	RB1	RB2	RB3	SEM	*P* value
pH	5.9	6.0	6.1	6.0	0.03	0.22
Cooking loss (%)	37.2	38.2	37.3	37.4	0.33	0.73
Drip loss (%)	8.1	8.0	8.1	8.0	<0.01	0.71
Water holding capacity (%)	37.2	29.6	32.7	32.8	0.99	0.10
TBARS	2.9^{d}	3.1^{c}	3.2^{b}	3.3^{a}	<0.01	0.01

Values are expressed as means (cage=n=4). Values in the same row with different superscripts are significantly different at $P < 0.05$. SEM: Standard error mean. TBARS: 2-Thiobarbituric Acid-Reactive Substances. CD: Control diet (Corn-soy-based control diet without rice bran). RB1: Diet containing rice bran stored for <24 hours, RB2: Diet containing rice bran stored for 1 week, RB3: Diet containing rice bran stored for 30 days.

Table 7: Breast meat colour of broiler chicken fed experimental diets for 35 days

	CD	RB1	RB2	RB3	SEM	*P* value
CIE[3] – L* values	39.6	41.0	38.7	40.9	0.37	0.06
CIE[3] – a* values	-1.9	-1.2	-1.2	-1.1	0.13	0.22
CIE[3] – b* values	3.7	3.7	2.8	3.0	0.14	0.05

Values are expressed as means (cage=n=4). Values in the same row with different superscripts are significantly different at P < 0.05. SEM: Standard error mean. CIE = Commission international de l'Eclairage, L* = Lightness, a* = Redness/greenness, b* = Yellowness/blueness. CD: Control diet (Corn-soy-based control diet without rice bran). RB1: Diet containing rice bran stored for <24 hours, RB2: Diet containing rice bran stored for 1 week, RB3: Diet containing rice bran stored for 30 days.

DISCUSSION

The global human population is projected to reach approximately 9.3 billion by the year 2050 (United Nations Department of Economic and Social Affairs 2017), which has created a need to enhance food production significantly. Chicken meat, characterized by its low-fat content and minimal cholesterol levels, serves as a promising source to cater for the growing demand for animal protein (Marangoni *et al.,* 2015). The formulation of diets plays a crucial role in broiler chicken production. Typically, a diet consists of a variety of feed components that provide essential energy and nutrients, including crude protein, fats, fibre, minerals, and vitamins necessary for the optimal growth of broiler chickens. Predominantly, cereals and oilseed meals constitute the primary components of animal diets, serving as sources of energy, protein, and other vital nutrients (Pesti and Choct, 2023). In the United States and across much of North America, animal diets are primarily formulated using corn and soybean meal. In other regions like Canada, Europe, South America, and various parts of the world, ingredients such as wheat, barley, canola meal, and distillers' dried grains with soluble are also utilized (Kiarie and Nyachoti, 2009). Nevertheless, there is a competitive demand for these feed ingredients in the food, biofuel, and bioprocessing sectors, leading to a gradual rise in costs over time (Borowski *et al.*, 2016 and Woyengo *et al.,* 2014). Hence, there is considerable potential to utilize co-products and by-products from the food and biofuel industries, often of limited or no value for human consumption, as alternative feed ingredients for broiler chickens, at least to a certain extent (Kiarie and Nyachoti , 2009).

In the present study, the inclusion of rice bran stored for 30 days increased the TBARS value of broiler diets indicating the occurrence of lipid oxidation. In accordance, Wu *et al.* (2020) also showed that fresh rice bran stored at room temperature for up to 10 days developed rancidity. During storage, rice bran can undergo hydrolytic and oxidative rancidity (Rodchuajeen *et al.,* 2016). Hydrolytic rancidity refers to the breakdown of lipids through hydrolysis, resulting in the release of free fatty acids (Bhunia *et al.,* 2023). This process can be induced by factors such as mechanical agitation, high temperature, and the presence of certain drugs (Ahmad *et al.,* 2010). On the other hand, oxidative rancidity involves the oxidation of lipids, leading to the formation of lipid peroxides (Deeth and Fitz-Gerald, 2006). Immediately after the rice milling, lipase in rice bran hydrolyzes the 1,3-site of triacylglycerol, resulting in the timely execution of free fatty acids (Rodchuajeen *et al.,* 2016; Thanonkaew *et al.,* 2012) leading to oxidative rancidity.

The current findings show that feeding broiler chickens with rice bran stored for 30 days can lead to a decline in their growth performance. The observed reduction in growth performance may be attributed to the development of rancidity in the rice bran during the extended storage period. These findings align with Chae *et al.* (2002), who observed similar performance declines in broilers fed rancid rice bran. The presence of oxidative by-products potentially reduces feed palatability (Godber *et al.,* 1993), which could explain the observed decrease in feed intake and subsequent growth. Furthermore, it is hypothesized that the oxidative degradation of fat-soluble vitamins (Lin *et al.,* 1989; Cheeke, 1991) may have diminished the micronutrient supply and compromised the birds' immune status, further contributing to the poor growth performance. However, further studies measuring specific vitamin concentrations and feed sensory profiles are needed to confirm these specific pathways. According to Yokochi, (1972), feeding rancid rice bran might induce gut problems, and negatively affect nutrient utilization and growth performance.

The enlarged intestinal segments observed in the birds fed rice bran stored for 30 days likely reflect a compensatory physiological response to the deleterious components of rancid rice bran. Prolonged storage facilitates lipid and protein oxidation, generating reactive oxygen species (ROS) such as malondialdehyde (MDA) that induce oxidative stress and damage the intestinal mucosa (Wang *et al.,* 2024; Mishra & Jha, 2019). This damage triggers an inflammatory cascade, characterized by cytokine release and mucosal edema, which contributes to the increased tissue mass (Tan *et al.,* 2019). Furthermore, this can be an adaptation of the digestive tract of broilers to acquire more nutrients from the diet. Previous studies have shown that oxidized soybean oil increased liver weight in broiler chicken (Diaz 1977; Hussein and Kratzer 1982).

Meat quality, in terms of WHC, cooking loss, drip loss, pH, and colour, was not affected by the inclusion of rice bran stored for extended periods in broiler chicken diets, indicating that the storage time of rice bran may not be sufficient for disclosing any significant effect in meat. Nevertheless, rice bran stored for 30 days caused higher TBARS values in breast meat. The meat TBARS values back up the findings of Lin *et al.* (1989), who discovered that lipid peroxidation rates in broiler muscles were substantially greater when fed oxidized oil.

CONCLUSIONS

The inclusion of rice bran stored for 30 days in diets can have adverse effects on the growth performance and meat TBARS values of broiler chickens, but no impact on other meat quality parameters. Feeding of rice bran stored for up to 1 week caused no negative impact on growth performance and meat quality in broiler chicken.

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COMPETING INTERESTS

The authors declare that they have no competing interests.

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