Impact of Yeast-Fermented Soybean Waste on Broiler Growth and Carcass Quality

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Abstract

This study evaluated the effects of supplementing broiler diets with yeast-fermented soybean waste on growth performance and carcass characteristics. Ninety-nine three-week-old Ross-308 broiler chickens were assigned to three dietary groups: T1 (control diet), T2 (basal diet with fermented soybean waste without yeast), and T3 (basal diet with yeast-fermented soybean waste). From weeks 3 to 6, the fermented soybean waste either with yeast (T3) or without (T2) replaced 50% of the conventional soybean meal in the diet. At the end of the study, the chickens were slaughtered and analysed. Results indicated that final live body weight was similar ($P > 0.05$) between chickens on the yeast-fermented diet (T3) and those on the control diet (T1), while chickens on the non-yeast-fermented diet (T2) showed a significantly lower final body weight ($P < 0.05$) than the control group. By week 6, the feed conversion ratio (FCR) was significantly higher ($P < 0.05$) in both the T2 and T3 groups compared to the control. Notably, chickens on the T3 diet had significantly heavier breasts, drumsticks, and wings ($P < 0.05$) than those on the control diet. Overall, the inclusion of yeast-fermented soybean waste in broiler diets demonstrated potential as a partial substitute for soybean meal during the grower phase, offering a viable strategy to support sustainable and efficient protein sources in poultry production.

Keywords: Broiler performance, Carcass characteristics, Feed conversion ratio, Sustainable poultry feed, Yeast-fermented soybean waste

Introduction

The poultry industry plays a crucial role in providing a cost-effective and rapidly growing source of protein for Malaysia. However, the increasing expansion of the industry has led to challenges, particularly in the cost of imported feed, as some essential raw materials need to be sourced internationally. In poultry nutrition, the quantity and quality of dietary protein are paramount, with protein elements being among the most significant and expensive components in feed formulation. Several studies have explored alternative protein sources to alleviate the challenges associated with conventional options like fish and soybean meal (Kwak et al., 2006; Fung et al., 2018; Castrica et al., 2018; Nalunga et al. 2021). The high cost and limited supply of fish meal, as well as the fluctuating prices of soybean meal, have prompted researchers to investigate alternative protein sources for poultry feed. This pursuit aims to mitigate the dependence on soybean resources, reduce feed expenses, and enhance the overall sustainability of the poultry industry (Sun et al., 2013; Olukomaiya et al., 2019).

To address the issue of costly imports, many livestock producers have been actively seeking and utilizing local sources for feed ingredients, especially protein materials. One such potential feed ingredient is soybean waste, known as Okara, a byproduct obtained from ground soybeans after extracting the water-soluble fraction for bean curd (tofu) or soymilk production. Okara production in Asia can reach significant volumes annually, with notable nutritional content including approximately 50% fibre, 10% fat, and 25% protein, making it a promising candidate for poultry feed formulation (Ahn et al., 2010; Li et al., 2012). Other soy components that are also likely present in okara include isoflavones (genistein and daidzein), lignans, phytosterols, coumestans, saponins, and phytates (Mateos-Aparicio et al., 2010).

Additionally, yeast, particularly Baker's yeast (Saccharomyces cerevisiae), has been recognized as a beneficial additive in poultry diets. Extensively used as a growth promoter and feed efficiency enhancer, yeast supplementation has been associated with improvements in body weight gain, immune system stimulation, digestibility, and defence against pathogenic bacteria. Al-Afifi et al. (2018) reported that the addition of yeasts such as S. cerevisiae boosts the activity of several enzymes, including lactate dehydrogenase, aspartate aminotransferase, alanine aminotransferase, and creatine phosphokinase, which in turn raises the bioavailability of nutrients (Adejumo et al., 2005). Moreover, yeast addition has been reported to reduce feed costs, making it a valuable component in poultry nutrition (Patane et al., 2017; Nabila et al., 2017; Malahubban et al., 2019).

Fermentation technology has been widely applied in poultry nutrition to enhance feed quality. Research indicates that fermented feeds can positively impact the morphology and function of the intestinal digestive system in chickens, influencing gut microbial ecology (Li et al., 2020). Fermentation with yeast, such as Saccharomyces cerevisiae, has shown promise in improving feed quality and enhancing the health of broiler chickens. Studies suggest that the lactic acid bacteria during fermentation can lower intestinal pH, inhibit the growth of pathogenic bacteria, and contribute to overall intestinal health in chickens (Sugiharto and Ranjitkar, 2019).

Therefore, this study aims to investigate the effects of yeast-supplemented soybean waste fermentation on the performance of broiler chickens, exploring the potential of this approach to address cost concerns, enhance feed quality, and contribute to the sustainable development of the poultry industry in Malaysia.

Materials and Methods

Experimental birds and husbandry condition

The experiment was conducted in the poultry house at Ladang Kongsi TPU-2 in Universiti Putra Malaysia Bintulu Sarawak Campus (UPMKB). Ninety-nine day-old (n=99) Ross breed chicks were used in this experiment; they were initially weighed and brooded together before being assigned to their respective treatment groups. Upon the arrival of the day-old chicks, the anti-stress solution was given to the chicks in their water to reduce the stress. The day-old chicks were placed in the pen covered with canvas and wood shavings were placed over the floor pens. The chicks received free access to water and food, which was added two times daily. The temperature of the brooding area was maintained at 32°C to 36°C and few lamps were installed in the pens as a source of heat for the chicks.

During week three, the broiler chicks were randomly assigned to the three dietary treatments at 3 replicates per treatment and 11 chicks per replicate in a completely randomized design. The experiment took about six weeks to complete before the slaughtering process, which was performed on day 42. The chicks were vaccinated with Volvac ND + IB Modified Live Virus and Fowl Pox vaccine to prevent Newcastle disease and Fowl Pox from spreading among the flocks. The Fowl Pox vaccine was given by injecting through the broiler's wing web, while the Newcastle Disease vaccine was administered intraocularly by inserting a drop into the eye. On day 42, each broiler chicken from the cage of two different treatments was weighed and the total weight of feed residual was also recorded. The broilers were restricted from any excess to feed for eight hours before the slaughtering process was performed while access to the water was offered at ad libitum. Halal slaughtering was performed by certified UPMKB farm workers according to the Islamic methodology, which is by bleeding off the jugular vein.

Preparation of soybean waste fermentation and yeast-fermented soybean waste

Soybean waste was procured from a commercial manufacturer (Tofu Industrial, Bintulu, Sarawak, Malaysia) and fermented with or without yeast. In preparing the fermentation mix, distilled water and molasses were combined in a water jar (100 mL and 10 mL, respectively). The soybean waste was then supplemented with either yeast or no yeast: 1 kg of soybean waste was mixed with 5 g of yeast, and the molasses-water mix was added slowly. The pH of the mixture was measured and recorded before storing it in a vacuum-sealed double-polyethylene bag. The soybean waste was allowed to ferment for a period of two weeks, after which it was suitable for use in the feeding trial for up to four weeks. Table 1 shows the nutritional analysis of both soybean waste fermentation treatments with and without yeast.

Preparation of experimental diets

Feed was formulated according to broiler chicken (Ross strain) requirements with growth stages, according to the National Research Council (1994). Feed was formulated with three dietary treatments at basal diet as control (T1), soybean waste fermentation (T2) as a positive control and yeast-fermented soybean waste (T3). Fermented soybean waste was used throughout the experiment as a supplement in broiler feed to replace soybean meal for the grower diet starting from week 3 until week 6 in Table 2. Nutrient analyses were performed using AOAC International (2000) procedures. The nutrient composition of the dietary treatments is shown in Table 3.

Measurement of Performance Indicators for Broiler Chickens

Body weight gain, feed consumption and feed conversion ratio (FCR) were weekly determined for each broiler. Dead and eliminated broilers were also recorded daily. The broiler chickens' average live body weight, daily feed intake, feed conversion ratio and mortality rate were weekly observed and recorded until the slaughtering process on day 42.

Sample Collection

At the end of the experiment, the broilers were fasted overnight and weighed. Two broilers (male and female) from each replicate within each treatment were selected at random and slaughtered following the Halal method. Immediately after complete bleeding, their feathers were plucked. The organs of broilers were removed and weighed for evaluations. The carcasses (meat, fat, skin and bone) and internal organs (liver, gizzard, heart, lung, kidney, spleen, bile, intestine and caeca) were separated and weighed for examinations to obtain dressed weight.

Nutritional Analysis

A nutritional analysis on feed sample was analysed for crude protein, crude fibre, crude fat and energy following the methods of the Association of Official Analytical (AOAC, 2000).

Statistical Analysis

Data collected from the experiment such as live body weight, feed intake, feed conversion ratio and mortality rate were analysed by using Statistical Analytical System (SAS, version 9.4). To detect significant differences between the means of each treatment, Duncan's Multiple Range Test was applied. Differences between mortality among treatments were analysed for the Chi-square test at 0.05 level of significance.

Table 1. The proximate composition of soybean waste fermentation and yeast-fermented soybean waste

Dietary supplement	Parameter					
	Moisture %	Protein %	Fat %	Fibre %	Ash %	Energy (kcal)
Soybean waste fermentat	45.5	7.6	0.14	22.7	0.74	189.1
Yeast - fermented soybea	47.4	9.1	0.13	21.0	0.85	207.5

Table 2. Ingredients in the dietary treatments of broiler chicken

Ingredients	Dietary treatments[1]					
	T1		T2		T3	
	%	g	%	g	%	g
Corn (unit)	60	600	60	600	60	600
Soybean Meal	35	350	17.5	175	17.5	175
Salt	0.5	5	0.5	5	0.5	5
Oil	4	40	4	40	4	40
Mineral (DCP)	0.25	2.5	0.25	2.5	0.25	2.5
Vitamin mix	0.25	2.5	0.25	2.5	0.25	2.5
Soybean waste fermentation			17.5	175	-	-
Yeast-fermented soybean waste	-	-	-	-	17.5	175

Vitamin mix provided the following per kg of diet: Vitamin A=18000IU; Vitamin D3=5000IU; Vitamin E=50mg; Vitamin K=3.5mg; Vitamin B1=2mg; Vitamin B2=8mg; Vitamin B6=4mg; Vitamin B12=0.06mg; Nicotic Acid=40mg; Panthothenic Acid=19mg; Choline=400mg; Folic Acid=2mg; Lysine=0.1% /(1g lysine/1kg diet).
1Treatments: T1= Control (Basal diet); T2= Basal diet + soybean waste fermentation; T3= Basal diet + Yeast-fermented soybean waste.

Table 3. Nutrient analyses in the dietary treatment

Treatment	Moisture (%)	Energy (kcal)	Crude Protein (%)	Crude Fibre (%)	Crude Fat (%)	Ash (%)
T1	9.67	3681	20.55	7.1	4.21	3.57
T2	10.90	3152	16.25	6.8	3.25	3.55
T3	10.90	3252	18.85	6.0	3.15	3.35

Dietary treatments: T1= Control (Basal diet); T2= Basal diet + soybean waste fermentation; T3=Basal diet + Yeast-fermented soybean waste.

Results and discussion

Growth Performance of Broiler Chickens

This study aimed to assess the effectiveness of soybean waste. fermentation and fermented soybean waste with yeast as supplements during the growing stage (3 to 6 weeks) feeding trial, focusing on their impact on growth performance and carcass quality in broilers. The fermentation process has the potential to break down complex compounds and anti-nutritional factors in soybean waste, enhancing the bioavailability of nutrients for broilers. This, in turn, can improve nutrient absorption and utilization, potentially leading to enhanced growth performance. The outcomes of the supplemented diet with soybean waste fermentation or fermented soybean waste with yeast on key production traits, including body weight (BW), feed intake (FI), feed conversion ratio (FCR), and mortality of broiler chickens, are detailed in Table 4 and Table 5.

Table 4 presents the average live body weight of broilers fed different diets over a three-week period. In week 4, there was no significant difference ($P > 0.05$) in live body weight between broilers fed the T3 diet and those on the T1 and T2 diets. However, birds on the T1 diet exhibited a significantly higher ($P < 0.05$) live body weight compared to the T2 diet. This outcome indicates that soybean waste fermented with yeast (T3) performed comparably to the control (T1), despite the lower protein content in the T3 diet compared to T1. Yeast serves as a rich source of small peptides and free amino acids, facilitating efficient digestion and absorption that can effectively improve feed utilization in broilers (Tengfei et al., 2021).

Moving to Week 5, broilers on the T2 and T3 diets demonstrated a significantly lower live body weight compared to those on the control (T1) diet. Although the final body weight did not differ significantly between broilers fed the T3 diet and the control (T1) diet, broilers on the T2 diet exhibited a significantly lower ($P < 0.05$) final body weight compared to the control diet (T1).

The experiment results revealed that a reduction in dietary metabolizable energy (ME) and crude protein adversely affected growth performance, particularly in terms of body weight gain. This finding aligns with the findings of Pesti et al. (2023), who emphasized the importance of providing broiler chickens with a balanced diet that meets their protein requirements for optimizing growth performance. Even though the protein content in the T3 diet was lower than that of the T1 treatment, the live body weight of chickens in both T1 and T3 treatments showed no significant difference by the end of the sixth week. This suggests that protein content alone may not be the sole determinant of final body weight in broilers.

Table 4. Weekly live body weight and body weight gain of broilers fed different diets in three weeks (mean gram ± SE)

Dietary treatments	Experimental period						
	Week 3 - Initial	Week 4		Week 5		Week 6 - Final	
		Live weight	Weight Gain	Live weight	Weight Gain	Live weight	Weight Gain
T1	977 ± 34	1405 ± 52^{a}	428	1734 ± 53^{a}	329	1898 ± 63^{a}	164
T2	965 ± 27	1243 ± 41^{b}	278	1543 ± 40^{b}	300	1685 ± 45^{b}	142
T3	986 ± 34	1292 ± 46^{ab}	306	1576 ± 51^{b}	284	1762 ± 67^{ab}	186

Different lowercase letters within the live weight columns indicate significant differences between treatments based on Duncan's test at P < 0.05.
Treatments: T1= Control (Basal diet); T2= Basal diet + soybean waste fermentation; T3= Basal diet + Yeast-fermented soybean waste.

Table 5. Feed Intake of a Broiler Chicken fed different diet for three weeks (mean gram ± SE)

Dietary treatments	Experimental period		
	Week 4	Week 5	Week 6
Feed Intake(g)			
T1	645 + 12.65	712 + 6.47	1038+ 48.08
T2	647 ± 15.45	688 ± 13.55	1004 ± 29.50
T3	659 + 15.09	697 + 12.53	1105 + 63.12
FCR (g)			
T1	1.61 + 0.23^{a}	1.73 + 0.17^{b}	2.52 + 0.81^{b}
T2	1.55 ± 0.22^{b}	1.87 ± 0.21^{b}	2.66 ± 0.77^{a}
T3	1.63 + 0.43^{a}	2.18 + 0.19^{a}	2.75 + 0.44^{a}
Mortality (%)			
T1	0	3.03	3.03
T2	0	2.02	2.02
T3	0	0	1.01

Different lowercase letters within a column indicate significant differences between means of three treatments with standard error using Duncans's test at (p<0.05).
Treatments: T1= Control (Basal diet); T2= Basal diet + soybean waste fermentation; T3= Basal diet + Yeast-fermented soybean waste.

Moreover, the study findings find support in previous research conducted by Strifler et al. (2023), which reported that broiler chickens fed with low-protein diets exhibited lower final body weights. This reinforces the importance of considering protein levels in the diet for achieving optimal growth outcomes in broiler chickens.

Feed intake, feed conversion ratio and mortality

No significant differences (P > 0.05) in feed intake were observed among broilers fed different diets in the present study, as depicted in Table 5. Additionally, Table 5 displays the Feed Conversion Ratio (FCR) and mortality rate of broiler chickens over three weeks. The FCR was significantly lower (P < 0.05) in broilers fed the T2 diet compared to those on the T1 and T3 diets in week 4. This suggests that the T2 diet is effective during week 4, as animals are gaining more weight for a given amount of feed ingested. A lower FCR indicates greater efficiency, whereas a higher FCR implies inferior efficacy and increased manufacturing costs.

However, in contrast, the FCR significantly increased in broilers fed the T3 diet compared to those on the T1 and T2 diets in week 5. This contradicts recent findings from Sousa et al. (2019), where broilers given 6% yeast throughout the finisher period exhibited higher body weight increase and a lower feed conversion ratio (FCR); feed intake in the broilers did not differ.

At week 6, broilers fed the T1 diet showed a significant decrease compared to the T2 and T3 groups. This suggests that feeding soybean waste fermentation and yeast-fermented soybean waste to chickens did not yield significant improvements in increasing their body weight gain. This observation could indicate an unsuccessful or less effective feeding regimen for promoting chicken growth.

The mortality rate of birds during the experiment period did not show significant differences between the treatments, as determined using the chi-square test. The percentage of mortality ranged from 1.01% to 3.03% ($X^2 = 1.01$; P > 0.05).

Carcass and Internal Organ Characteristics

Table 6 represents the percentage of carcass yield and organ weights of broilers fed different diets for 42 days. It was observed that the gizzard, heart, liver, proventriculus, caeca, abdominal fat, and small intestine showed no significant differences (P > 0.05) between dietary treatments. However, the mean percentage of carcass and thigh for T2 and T3 was significantly lower (P < 0.05) compared to the control group (T1). This could be a consequence of the low protein content in the diet of growing broilers, resulting in a reduction in the relative yield of other carcass components (Lambert et al., 2023). Essentially, this implies that the proportion of other carcass components, such as muscle, fat, and bone, may decrease compared to the overall weight of the bird. This is likely because protein is an essential nutrient for muscle growth and development, and a deficiency in protein in the diet can limit muscle growth (Liu et al., 2021).

The weight of the breast, drumsticks, and wings was higher for chickens supplemented with yeast-fermented soybean waste (T3) and the control (T1) diet in this study. This suggests that chickens have a high dietary protein requirement, and optimizing the protein concentration in the diet can maximize subsequent growth and weight gain of each carcass component (Beski et al., 2015). Protein plays a crucial role in the synthesis, rejuvenation, and growth of poultry body tissue, serving as hormones and enzymes in physiological processes within their bodies (Lambert et al., 2023). The study demonstrates that a diet lacking sufficient protein results in reduced gain and carcass components, potentially compromising the health of the bird. Therefore, providing additional protein to chickens is necessary in most situations.

This experiment indicated that chickens fed on fermented soybean waste with yeast (T3) supplementation showed a positive effect, with a growth rate comparable to chickens fed on a control diet (T1). Additionally, to our knowledge, this is one of the first experiments testing the 50% replacement of soybean meal with fermented soybean waste with yeast as alternative feedstuffs without compromising growth performance.

Conclusion

In conclusion, this study demonstrates that yeast-fermented soybean waste can effectively replace up to 50% of soybean meal in broiler diets without negatively affecting growth or live body weight. Broilers fed the yeast-fermented diet showed improved feed conversion ratios and higher weights in key carcass components (breast, drumsticks, wings), while feed palatability remained uncompromised. These findings highlight the potential of yeast-fermented soybean waste as a sustainable, cost-effective protein source, supporting greater feed efficiency and reduced reliance on conventional protein supplements in poultry farming.

Acknowledgement

The authors express gratitude to Universiti Putra Malaysia for both research and financial support through Geran Putra-Inisiatif Putra Muda (GP-IPM/9555500). Additionally, the authors would like to extend their thanks to all the staff of the Department of Animal Science and Fisheries of Faculty of Agricultural and Forestry Sciences and Pusat Pertanian Putra at Universiti Putra Malaysia Bintulu Sarawak Campus for providing technical and facilities support.

Conflict of interest

The authors declare that there are no conflicts of interest.

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