



Effects of Broiler by-Product-Based Concentrate on Feed Conversion Ratio, Weight Difference and Meat Quality of Bali Local Pigs

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Abstract | This study aimed to evaluate how the effects of substituting commercial concentrate (CC) with broiler by-product-based concentrate (BBBC) on the feed conversion ratio (FCR), weight difference (WD), and meat quality of Bali local pigs. A completely randomized design (CRD: 4×5) was used, with four treatments: T0 (ration with 24% CC and 0% BBBC), T1 (ration with 16% CC and 8% BBBC), T2 (ration with 8% CC and 16% BBBC), and T3 (ration with 0% CC and 24% BBBC). Each treatment was replicated five times, involving 20 Bali local pigs with an average body weight of 14.39 ± 0.79 kg. The research parameters included the feed conversion ratio (FCR), weight difference (WD) between final body weight (FBW) and slaughter weight (SW), and the meat quality of Bali local pig. The results showed that substituting CC with 8%, 16%, and 24% BBBC did not significantly affect FCR, WD, or meat quality parameters such as pH, water content, and ash content compared to the control group ($P > 0.05$). However, substitution with 16% and 24% BBBC significantly increased drip loss (T2: 12.77% and T3: 11.93%), cooking loss (T2: 40.02% and T3: 40.12%), and meat fat content (T2: 5.45% and T3: 5.89%) ($P < 0.05$) while decreasing water-holding capacity (T2: 32.98% and T3: 33.34%) and protein content (T2: 22.32% and T3: 22.12%) ($P < 0.05$). Substitution of CC with 24% BBBC can maintain FCR, WD values and pH, water content, ash content, but reduces the meat quality of Bali local pig. It is recommended to substitute with 24% BBBC to maintain FCR and WD, pH, ash content, water content and substitute with 8% BBBC to get optimal quality of Bali local pig meat.

Keywords | Bali local pig, Feed conversion ratio, Meat quality, Broiler by-product-based concentrate, Weight difference

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INTRODUCTION

Bali local pigs are indigenous to the province of Bali, Indonesia, and are classified as lard-type pigs. They

have long been raised by the Balinese people as a side business, for utilizing leftover household feed, and as ceremonial livestock (Sudiastra and Budaarsa, 2021; Sumardani *et al.*, 2022; Sabat *et al.*, 2024; Dalle *et al.*, 2024). Bali local

pigs require approximately 12 months to reach a body weight of up to 80 kg, whereas purebred or improved pigs can reach a weight of 80–110 kg in just 5–6 months (Candrariarta *et al.*, 2021; Ariana *et al.*, 2023a). Research to enhance the performance, productivity, feed intake, feed conversion ratio (FCR), and blood profiles of pigs through the use of agricultural waste and other feed alternatives has been conducted (Pieroza *et al.*, 2020; Wibawa and Sumadi, 2019; Cuibi *et al.*, 2021; Mahardika *et al.*, 2023; Ariana *et al.*, 2023b; Loan and Phuong, 2024). Efforts to increase the productivity of Bali local pigs, particularly in achieving optimal body weight and meat quality according to their genetic potential, have included the use of commercial concentrate mixtures in their rations (Candrariarta *et al.*, 2021; Dalle *et al.*, 2024). However, feed costs account for 70%–80% of the total cost of pig farming (Ariana *et al.*, 2023a; Vasyi *et al.*, 2024), which presents a significant challenge due to the high price of commercial concentrates and the limited availability of affordable alternative feed sources with comparable nutritional content (Mahardika *et al.*, 2023; Ariana *et al.*, 2023a). Broiler chicken farming generates by-products such as rejected chickens, physically disabled and dead chickens, and litter mixed with spilled feed around the feeding area. These by-products if are not handled properly they will cause serious environmental problems. If processed and handled well, it has great potential as a source of feed concentrate due to safe and their favorable nutritional content (Oka *et al.*, 2023; Ariana *et al.*, 2023b). Research has shown that physical processing, such as grinding into flour, sun-drying, oven-drying, or fermentation, can enhance the nutritional value and safety of broiler by-products for use in animal feed. The resulting product, referred to as Chicken Waste Protein Concentrate flour, contains 39.70% crude protein and a metabolic energy (ME) value of 5110 kcal/kg (Oka *et al.*, 2023). Protein concentrates from chicken farm waste good for use as mixed ration for monogastric animals (pigs) and has been trialled and can maintain the performance and blood profile of landrace pigs (Ariana *et al.*, 2023a, b), and the performance and primal cut of Bali local pigs (Ariana *et al.*, 2023c). The problem of high price of commercial concentrates and the limited sources of alternative concentrates in Bali local pig farms, there is no research on the potential and benefits of concentrates based on broiler farm by-products (BBBC), so it is necessary to try BBBC on Bali local pigs. This research needs to be tried and is the first to try BBBC on Bali local pigs with the aim of evaluating its effect on FCR, weight loss during the time before slaughter (with 12 hours of fasting), and the quality of Bali pig meat.

MATERIALS AND METHODS

The study was conducted for 55 days at the Teaching Farm of the Faculty of Animal Husbandry, Udayana Uni-

versity, using 20 castrated males Bali local pigs in the grower phase. The pigs had an average body weight of 14.39 ± 0.79 kg. Each pig was housed in an individual cage, with feed management tailored to intake, treatment, and the ergonomic needs of Bali local pigs in the grower phase.

LONGISSIMUS DORSI MEAT SAMPLES

Meat quality tests were conducted using samples from the longissimus dorsi muscle. A total of 40 meat samples, representing 4 treatments with 10 replicates each, were analyzed. The physical properties of the meat evaluated included water-holding capacity (WHC), drip loss (DL), cooking loss (CL), and pH value. Testing the pH value followed the Ockerman's method (Soeparno, 2015), which involved dissolving 5 g of a meat sample in 45 ml of distilled water for 2 minutes. The pH meter electrode was then immersed in the solution until a stable reading was obtained. The percentage of WHC was calculated using the formula from Lorenzo *et al.* (2015) and Soeparno (2015):

$$\%WHC = (1 - \frac{WLC + WLC}{TM}) \times 100$$

Where;

WLC: Weight of cooked sample lost after centrifugation (% of the initial weight of the fresh meat sample).

WLC: Weight lost after cooking (% of the initial weight of the fresh meat).

TM: Total water content of the fresh meat sample, determined by measuring the weight lost after heating at 105°C for 18 hours.

Cooking loss (CL) was calculated as the weight difference between the meat before and after cooking, divided by the initial weight, and expressed as a percentage.

Table 1: Nutrient content of commercial concentrate (CP.152 for grower pig fase), and BBBC.

Nutrient	water (%)	ash	CP	Fat	CF	Ca	P	ME K. cal/kg
CC*)	12.0 max	20.0 max	37.0 min	3.0 min	8.0 max	3.0-5.0	1.2-2.0	3654,0
BBBC**)	11.3	10.4	39.7	4.8	8.4	5.2	1.2	5110,0

Note: CC: Concentrate comersial for grower pig fase, BBBC: Broiler By-product-Based Concentrate; * Charoen Pokphand Company (2024), ** Oka *et al.* (2023).

BROILER BY-PRODUCT-BASED CONCENTRATE (BBBC)

Broiler by-product-based concentrate (BBBC) is a by-product of broiler chicken farming is a protein-rich feed concentrate (Table 1) made from rejected broiler chicken meal and litter meal, mixed with feed spills. In detail, the rejected chickens is cut into small pieces, ground, and oven-dried at 70°C for 48 hours. After drying, the meat was

ground into meat flour. Litter flour was produced by collecting litter, drying it in the sun until air-dried, and then grinding it into fine litter-powder. To enhance the nutritional value and safety of the feed as a ration component, the concentrate was fermented using an EM-4 fermenter (Figure 2). The composition of 100 kg of BBBC flour included 66.67 kg (two parts) of litter flour and 33.33 kg (one part) of rejected chicken meat flour. The commercial concentrate used in this study was produced by Charoen Pokphand Indonesia Company, under the product code CP-152 (Charoen, 2024). This concentrate served as a protein source for pig rations during the grower phase. The nutritional content of CP-152 and BBBC concentrates is shown in Table 1. (Oka *et al.*, 2023).

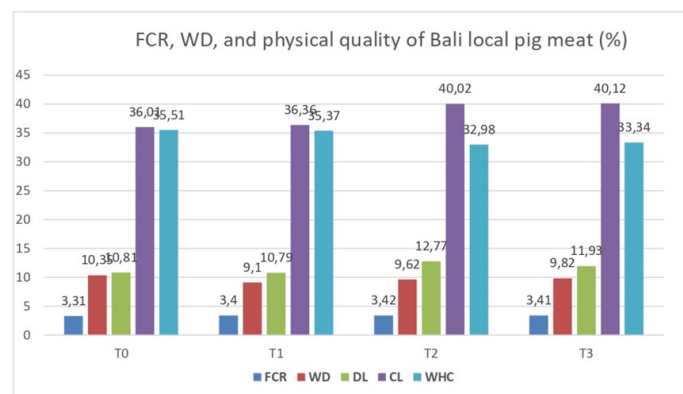


Figure 1: Chart, The effect of commercial concentrate substitution with BBBC on FCR, WD, and Physical quality of Bali local pig meat (%).

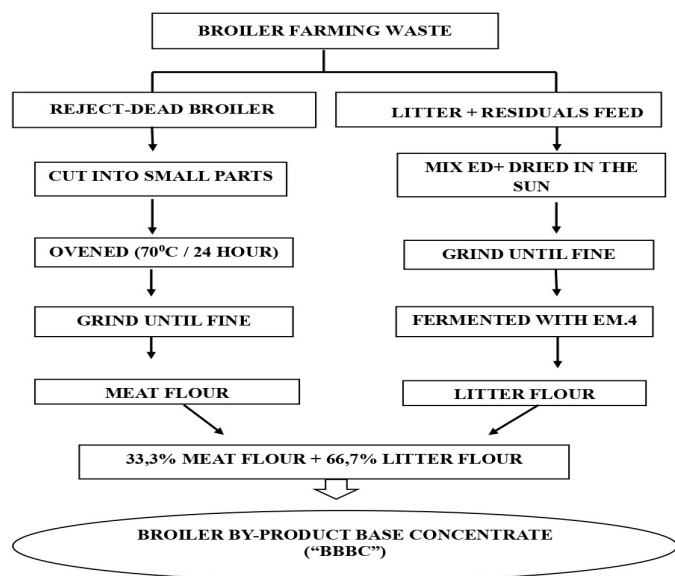


Figure 2: Process for Making Broiler By-product-Base Concentrate (BBBC).

RESEARCH DESIGN

The study employed a Completely Randomized Design (CRD) (4x5x1) with four treatments, each repeated five times, resulting in the use of 20 Bali local pigs in the grower

phase. The pigs had an average body weight of 14.39 ± 0.79 kg. The treatments were as follows:

Table 2: Composition of research rations.

Material	Treatment (%)			
	T0 (control)	T1	T2	T3
Concentrate Comersial 24*)		16	8	0
BBBC	0	8	16	24
Rice bran	35	35	35	35
Corn	40	40	40	40
Mineral-10	1	1	1	1
Total	100	100	100	100

*) Recommended use of commercial concentrates in grower pig rations (animal feed factory, Charoen Pokphand, 2024).

- Treatment T0: Ration containing 24% commercial concentrate + 0% BBBC.
- Treatment T1: Ration containing 16% commercial concentrate + 8% BBBC.
- Treatment T2: Ration containing 8% commercial concentrate + 16% BBBC.
- Treatment T3: Ration containing 0% commercial concentrate + 24% BBBC.

The composition and content of the treatment rations are as in Table 2, 3 and Table 4.

Table 3: Nutritional content of Bali local pig rations (according to treatment).

No	Nutrient	Units	Treatment*)				Stand-ard**)
			T0	T1	T2	T3	
1	Dry mater	%	86.71	87.73	85.59	86.77	-
2	Water content	%	13.29	12.27	14.41	13.86	Max. 14,00
3	Ash	%	6.31	7.12	7.31	7.78	Max. 8,00
4	Crude protein	%	18.86	17.78	17.41	18.56	Min. 15,00
5	Crude fiber	%	6.01	6.87	6.65	7.00	Max. 7,00
6	Crude fat	%	4.61	5.52	5.97	5.78	Max. 7,00
7	TDN	%	84.32	71.61	67.76	79.76	-
8	Metabolise energy	Kcal/ ME kg	3027.2	3149.1	3126.3	3354.11	Min. 2900

Note: *) Results of Proximate Analysis at Lab. Nutrition and Animal Food, Fapet. udayana University. **) Badan Standarisasi Nasional (SNI). 01-3914-2006 (standard ration for growing pigs).

RESEARCH PARAMETERS

The research parameters are, final body weight (FBW) namely the body weight obtained at the end of the re-

search, additional body weight (WG) namely the difference between body weight at the end of the study and body weight the beginning of the research, feed consumption (FC) namely the amount of feed consumed during the research, weight during the research, slaughter weight (SW) is the body weight before the pig is slaughtered and 12 hours of fasting, the weight difference (WD=FBW-SW) is the difference between final body weight and slaughter weight after fasting for 12 hours, meat quality (physical and chemical meat) of local Bali pigs in the grower phase as measured by the Ocherman method (Soeparno, 2015; Lorenzo *et al.*, 2015).

Table 4: The effect of commercial concentrate substitution with BBBC on FCR and weight difference(WD) of Bali local pigs.

Parameter (kg)	Treatment				
	T0	T1	T2	T3	SEM
IBW	14,92a	14,17a	14,01a	14,45a	0,19
FBW	42,90a	43,06a	42,92a	43,19a	0,35
WG (FBW-IBW))	28,92a	28,89a	28,91a	28,74a	0,45
FC	95,84a	98,24a	99,12a	98,14a	0,65
FCR	3,31a	3,40 a	3,42a	3,41a	0,11
SW	38,55a	39,14a	38,79a	38,95a	0,43
WD (FBW-SW) (kg)	4,35 ^a	3,92 ^a	4,13 ^a	4,24 ^a	0,15
WD(FBW-SW) (%)	10,35 ^a	9,10 ^a	9,62 ^a	9,82 ^a	0.15

Note: IBW: Initial Body Weight, FBW: Final Body Weight, WG: Weight Gain, FC: Feed Consumption, SW: Slaughter Weight, FCR: Feed Conversion Ratio, WD: Weight Difference; SEM: Standard Error of the Treatment Means.

STATISTICAL ANALYSIS

The research results were analyzed using analysis of variance (one way ANOVA), and if there were significant differences between the treatments ($P < 0.05$), it would be followed by Duncan's multiple range test at the 95% confidence level (Steel and Torrie, 2017). The analysis procedure used SPSS program version 23.0.

ETHICAL APPROVAL

The study received ethical approval from the Animal Ethics Committee of the Faculty of Veterinary Medicine, Udayana University, Bali. The animal ethics approval certificate number is B/174/UN14.2.9/PT.01.04/2024.

RESULTS

FCR AND WEIGHT DEFFERENCE

Feed conversion ratio (FCR) is a key indicator of live-stock productivity and efficiency in feed utilization. FCR is calculated as the ratio of feed consumed to weight gain achieved during the maintenance period (Pierozan *et al.*, 2016; Pratama *et al.*, 2022). Weight def-

ference (WD) refers to the difference between the final body weight (FBW) at the end of the maintenance period and the slaughter weight (SW) after a 12-hour fasting period.

The effect of substituting commercial concentrate with broiler by-product-based concentrate (BBBC) is presented in Table 4. Substitution 8%, 16%, and 24% BBBC in treatment groups T1, T2, and T3, respectively, did not significantly affect the final body weight (FBW) of Bali local pigs compared to the control group (T0) ($P > 0.05$). Similarly, no significant differences were observed in weight gain (WG) and feed consumption (FC) among the treatment groups (T1, T2, and T3) and the control group (T0) ($P > 0.05$). Regarding the feed conversion ratio (FCR), there were no significant differences among the treatment groups (T1, T2, and T3) or between the treatment groups and the control group (T0) ($P > 0.05$).

Substitutions of 8%, 16%, and 24% BBBC resulted in Bali local pig slaughter weights that were almost identical across treatments (T1, T2, T3) and comparable to the control group (T0) ($P > 0.05$). The weight difference (WD), calculated as $FBW - SW$, was 4.35 kg or 10.35% in the control group. In groups T1, T2, and T3, the weight differences were 9.10%, 9.62%, and 9.82%, respectively ($P > 0.05$). Statistically, the WD values for all treatment groups were similar to the control group ($P > 0.05$).

PHYSICAL QUALITY OF MEAT

The physical quality of Bali local pig meat was assessed based on meat pH value, drip loss (DL), cooking loss (CL), and water holding capacity (WHC) (Table 5) (Soeparno, 2015; Ariana *et al.*, 2023b). Substitution of commercial concentrate with 8%, 16%, and 24% BBBC (T1, T2, T3) resulted in similar pH values among the treatment groups, which were also comparable to the control group (T0) ($P > 0.05$).

Table 5: The effect of commercial concentrate substitution with BBBC on meat physical quality of Bali local pigs.

Physical quality (%)	Treatment				SEM
	T0	T1	T2	T3	
pH	5,75 ^a)	5,68a	5,55 a	5,51 a	0,03
Drip Loss	10,81 ^b	10,79b	12,77a	11,93a	0,14
Cooking Loss	36,01 ^b	36,36b	40,02a	40,12a	0,15
Water Holding Capacity	35,51 ^a	35,37a	32,98b	33,34b	0,49

Note: *)Values with superscripts on the same row are not significantly different ($P > 0.05$); SEM: Standard Error of the Treatment Means.

Substitution 8% BBBC (T1) resulted in a drip loss (DL) of 10.79%, which was not statistically different from the control group (T0) ($P > 0.05$). However, substitutions of

16% and 24% BBBC (T2 and T3) caused an increase in DL, which was significantly higher than the control group ($P < 0.05$). A similar pattern was observed with cooking loss (CL). Substitutions of 16% and 24% BBBC caused a significant increase in CL (T2: 40,02% and T3: 40,12%) and a corresponding decrease in water holding capacity (WHC, T2: 32,98% and T3: 33,34%) compared to the control group ($P < 0.05$) Table 5. In general, the effect of BBBC substitution on FCR, WD, and physical quality of Bali local pig meat is as shown in Table 7 and Figure 1.

CHEMICAL QUALITY OF MEAT

The chemical quality of Bali pig meat was evaluated based on parameters such as water content, fat content, protein content, and ash content (Table 6). Substitutions of 8%, 16%, and 24% BBBC (T1, T2, T3) resulted in similar water content across treatments, which was also comparable to the water content of the control group (T0) ($P > 0.05$). A similar trend was observed for ash content, where no significant changes were found among the treatment groups (T1, T2, T3) compared to the control group ($P > 0.05$). Substitution with 8% BBBC (T1) resulted in a meat fat content of 4.28%, which was lower than that of the control group, though not significantly ($P > 0.05$). However, increasing the substitution to 16% and 24% BBBC (T2: 5,45%, T3: 5,89%) significantly increased the fat content of the meat, making it higher than the fat content of the control group ($P < 0.05$).

Table 6: The effect of commercial concentrate substitution with BBBC on the meat chemical quality of Bali local pigs.

Chemical quality (%)	Treatment				SEM
	T0	T1	T2	T3	
Water	68,70a [*]	69,68a	69,80a	69,11 a	0,49
Fat	4,55 b	4,28b	5,45 a	5,89 a	0,15
Protein	23,84 a	23,22a	22,32b	22,12 b	0,17
Ash	2,91 a	2,82a	2,45 a	2,88 a	0,07

Note: *) Values with superscripts on the same row are not significantly different ($P > 0.05$). **SEM:** Standard Error of the Treatment Means.

Table 7: The effect of commercial concentrate substitution with BBBC on FCR, WD, and Physical quality of Bali local pig meat (%).

	FCR	WD	DL	CL	WHC
T0	3,31 ^a	10,35 ^a	10,81 ^b	36,01 ^b	35,51 ^a
T1	3,4 ^a	9,1 ^a	10,79 ^b	36,36 ^b	35,37 ^a
T2	3,42 ^a	9,62 ^a	12,77 ^a	40,02 ^a	32,98 ^b
T3	3,41 ^a	9,82 ^a	11,93 ^a	40,12 ^a	33,34 ^b
SEM	0,11	0,43	0,14	0,15	0,49

Note: *) Values with superscripts on the same column are not significantly different ($P > 0.05$). **SEM:** Standard Error of the Treatment Means.

The protein content of meat in the T1 group was 23.22%, which was almost the same as that of the control group ($P > 0.05$). However, as the substitution level of commercial concentrate to 16% and 24% BBBC the protein content of the meat decreased significantly (T2: 22,32%, T3: 22,12%), becoming notably lower than that of the control group (T0) ($P < 0.05$) Table 6. In general, the effect of BBBC substitution on FCR, WD, and physical quality of Bali local pig meat is as shown in Table 7 and Figure 1.

DISCUSSION

FCR AND WEIGHT DIFFERENCE

Substitution with BBBC did not significantly affect the weight gain parameters of Bali local pigs (FBW-IBW) in treatment groups T1, T2, and T3, and these were statistically comparable to the control group (T0) ($P > 0.05$) (Table 4). This outcome can be attributed to the similar nutritional content in each treatment, particularly in crude protein, crude fat, and ration energy (ME). The high-quality nutritional content of the rations, meeting the pigs' standard dietary requirements, resulted in comparable weight gains across treatments during the grower phase ($P > 0.05$).

The crude protein content in the treatments was as follows: T0: 18.86%, T1: 17.78%, T2: 17.41%, and T3: 18.56%. These values exceed the minimum protein requirement for pigs in the growth phase, which is 15.00% (BSN, 2006). Similarly, the crude fat content was below the maximum permissible limit (7%), and the Metabolizable Energy (ME) values exceeded the minimum requirement (2900 Kcal/kg) (BSN, 2006). These findings align with Wibawa and Sumadi (2019); Huu Van *et al.* (2023), who reported that protein content, especially essential amino acids in the diet, positively impacts weight gain, FCR and performance. Additionally, the use of 24% basal concentrate derived from chicken farm waste in Landrace pig diets significantly increased weight loss during a 12-hour fasting period before slaughter ($P < 0.05$) (Ariana *et al.*, 2023c). Micro-mineral supplementation in basal diets has also been shown to enhance final body weight, increase weight gain, and reduce FCR (Partama, 2019; Hong *et al.*, 2023). The crude fiber content in the treatment rations, which remained below the maximum allowable limit (7%) (BSN, 2006), may explain the lack of significant effects of BBBC substitution in all treatment groups. Crude fiber, particularly lignocellulosic fiber, can increase villi height and intestinal length, thereby enhancing weight gain and reducing FCR (Agostini *et al.*, 2014; Ardana *et al.*, 2024).

Conversely, Ariana *et al.* (2023a) reported that substituting 100% commercial concentrate with 100% chicken farm waste concentrate significantly reduced performance pa-

rameters in Landrace pigs. This discrepancy may be due to breed differences, as Bali local pigs are indigenous to Bali Province and are adapted to lower-quality feed (Sudiastra and Budaarsa, 2021). Breed differences can influence up to 30% of livestock production (Soeparno, 2015; Marek *et al.*, 2022). In this study, all treatments involved the same breed, sex, age, and cage management, which contributed to statistically non-significant differences ($P > 0.05$) in weight gain and other performance parameters. This aligns with findings from Agostini *et al.* (2014) and Douglas *et al.* (2015), who emphasized that livestock and management factors are critical determinants of performance, FCR, and growth in grower-finisher pigs.

Feed consumption is significantly influenced by the palatability and nutritional composition of the ration, particularly the energy-to-protein ratio (ME/CP) (Soeparno, 2015). The rations used in this study had ME/CP ratio exceeding the minimum standard required for pigs in the grower phase (Table 3). The increased feed consumption observed in groups T1 and T2 may be attributed to their lower protein content and higher crude fiber content ($P > 0.05$). Feed consumption or intake is closely related to the protein and crude fiber content in the diet (Cuibi *et al.*, 2021). When dietary nutritional content is lower, pigs tend to consume more feed to meet their physiological needs. This condition can lead to increased daily feed consumption, subsequently affecting the FCR value and overall pig production. Feed intake and FCR are key production indicators in grower-finisher pigs (Silva *et al.*, 2017).

Almost the same feed consumption and weight gain among treatment groups T0, T1, T2, and T3 ($P > 0.05$) (Table 4) resulted in no statistically significant differences in feed conversion ratio between treatments ($P > 0.05$). FCR is determined by the amount of feed intake (FC) and the weight gain (achieved during the study (Silva *et al.*, 2017). Other factors, such as the uniform environment, cage conditions, feed form, and cage density across all treatments, contributed to the lack of statistical significance in FCR values among the groups (Table 4).

This observation aligns with the findings of Pierozan *et al.* (2016) and Pierozan *et al.* (2020), who reported that daily feed intake and FCR in growing pigs are influenced by pig welfare, cage density, feed form, and feeding location. They also noted that a cage density of up to 20 pigs per pen and poor pig welfare can negatively affect FCR. Moreover, livestock management plays a crucial role in determining the performance and growth of pigs during the grower-finisher phase (Agostini *et al.*, 2014; Douglas *et al.*, 2015; Mierlo *et al.*, 2021). The balance of amino acids, micro-mineral intake and the dietary combination of UFA-containing sources and natural antioxidants in basal rations has been shown to increase weight gain and reduce FCR and to im-

prove the quantity and quality of the pork (Wibawa and Sumadi, 2019; Partama, 2019; Ardana *et al.*, 2024; Nguyen *et al.*, 2024).

The weight difference (WD), calculated as FBW - SW, was 4.35 kg or 10.35% weight loss during 12 hours of fasting until the pigs were weighed before slaughter (SW) in the control group. Substitution in groups T1, T2, and T3 had no statistically significant effect on WD, with values comparable to the control group T0 ($P > 0.05$). This consistency can be attributed to the uniform livestock factors, housing, feed form, and feeding methods across all treatments.

Substitution 8% BBBC (T1) resulted in a drip loss (DL) of 10.79%, which was not statistically different from the control group (T0) ($P > 0.05$). However, substitutions of 16% and 24% BBBC (T2 and T3) caused an increase in DL, which was significantly higher than the control group ($P < 0.05$). A similar pattern was observed with cooking loss (CL). Substitutions of 16% and 24% BBBC caused a significant increase in CL (T2: 40.02% and T3: 40.12%) and a corresponding decrease in water holding capacity (WHC, T2: 32.98% and T3: 33.34%) compared to the control group ($P < 0.05$) Table 5. In general, the effect of BBBC substitution on FCR, WD, and physical quality of Bali local pig meat is as shown in Table 7 and Figure 1.

MEAT QUALITY

PHYSICAL QUALITY OF MEAT: The meat pH parameters in groups T0, T1, T2, and T3 ranged from 5.51 to 5.75 ($P > 0.05$), which falls within the normal pH range for pig meat (Soeparno, 2015) (Table 5). The decrease in pH observed in groups T2 (5.55) and T3 (5.51) significantly increased the DL (drip loss) and CL (cooking loss) values while decreasing the WHC (water-holding capacity) value ($P < 0.05$). The postmortem decline in muscle pH is primarily influenced by the rate of glycolysis and muscle glycogen reserves. Normal muscle pH ranges from 5.4 to 5.8 (Soeparno, 2015; Marek *et al.*, 2022). Feed conversion (FC) in the T1, T2, and T3 treatment rations (Table 4) was higher than in the control ration ($P > 0.05$), which correlated with the physical quality of the meat (pH, DL, CL, WHC). A higher crude fiber (CF) content in the ration may cause an increase in the pH, DL, and CL of Bali local pig meat (Table 5). These findings align with observations by Soeparno (2015), who reported that the nutrient content of the ration and feed consumption can affect meat pH between 3 to 5 hours postmortem. They also noted that low sodium content in the ration or restricted feed availability can result in higher pork pH and increased feed consumption. Conversely, higher crude fiber content in the ration can reduce meat quality, as evidenced by greater cooking loss (CL) and elevated meat pH. The CL parameter for Bali pig meat remained within the normal range of 1.5–54.5% (Soeparno, 2015). Generally,

factors pre-slaughter treatment and combination of UFA-containing sources and natural antioxidants in the pig ration can affect the physico-chemical properties and improve the quantity and quality of the pork (Povod *et al.*, 2021; Nguyen *et al.*, 2024). The relationship between physical quality parameters of Bali pig meat (pH, DL, CL, and WHC) (Table 5) is consistent with findings from Soeparno (2015), who stated that meat with high DL and CL values typically exhibits low WHC, and vice versa.

Such conditions are characteristic of lower-quality meat, as significant nutrient loss occurs during cooking. This is different from the research of Ariana *et al.* (2023b), that replacing up to 100 percent of commercial concentrate with concentrate based on broiler farm waste can increase pH, drip loss, cooking loss, and reduce the water holding capacity of landrace finisher pig meat. The difference in data is due to breed differences (Douglas *et al.*, 2015; Sumardani *et al.*, 2022).

CHEMICAL QUALITY OF MEAT: The water and ash contents of the treatment groups T0, T1, T2, and T3 were not significantly different, indicating no effect from substituting commercial concentrate with 8%, 16%, and 24% BBBC ($P > 0.05$). The water content of Bali local pig meat (Table 6) remained within the normal range for meat, 68%–80% (Soeparno, 2015).

The fat content of the meat in groups T2 (5.45%) and T3 (5.89%) was significantly higher than that in the control group (T0) (Table 6) ($P < 0.05$). This can be attributed to the higher metabolizable energy (ME) of the T2 and T3 rations (ME: 3226 Kcal/kg and 3354 Kcal/kg, respectively) compared to T0 (3027 Kcal/kg). The high energy content in the ration contributed to the increased fat content of pig meat (Table 6), which in turn influenced the higher cooking loss (CL) of pig meat (Table 5). This observation aligns with Soeparno (2015), who noted that animals with higher body fat content produce meat with greater cooking loss (CL).

The protein content of Bali local pig meat in groups T2 (22.31%) and T3 (22.12%) was significantly lower than that in the control group (T0) ($P < 0.05$) (Table 6). This reduction corresponds to the lower WHC observed in T2 and T3 (Table 5). A decrease in WHC is associated with increased CL, as the release of water from meat carries nutrients and proteins, resulting in reduced protein content (Soeparno, 2015). Fat content in meat is inversely proportional to its protein and water content. The ability of meat proteins to bind water affects the meat's water content, increasing drip loss (DL) and cooking loss (CL) (Soeparno, 2015). Pre-slaughter factors, including feed treatments, contribute to variations in meat quality (Povod *et al.*, 2021). This is different from the research of Ariana *et*

al. (2023b), that replacing up to 100 percent of commercial concentrate with concentrate based on broiler farm waste can reduce the chemical quality (water, protein, fat and ash content) of finisher phase landrace pig meat. The differences in data are due to breed differences (Douglas *et al.*, 2015; Sumardani *et al.*, 2022).

CONCLUSIONS AND RECOMMENDATIONS

Substitution of commercial concentrate with 24% BBBC had no effect on FCR parameters, weight difference (FBW - SW), and pH, water content, ash content of Bali local pig meat, the same as the control. Substitution with 24% BBBC caused a decrease in the psycho-chemical value of Bali local pig meat. To maintain FCR values and minimise weight loss of Bali local pigs before slaughter, it is recommended to substitute commercial concentrates with 24% BBBC. Farmers can substitute up to 8% BBBC without compromising meat quality. Future studies should investigate the long-term effects of BBBC on pig health and productivity.

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NOVELTY STATEMENTS

This study is the first to evaluate the effect of substitution of commercial concentrate with broiler by-product-based concentrate (BBBC) on feed conversion ratio, body weight difference and meat quality of Bali local pig.

AUTHOR'S CONTRIBUTIONS

I. N. T. Ariana, was fully responsible for conducting the research and writing the manuscript. G. A. M. Kristina Dewi processed the research data. N. L. P. Sriyani, collected the laboratory data. I. N. Sumerta Miwada and T. I. A. S. Ardani, edited the manuscript.

DATA AVAILABILITY

The datasets used and/or analyzed during the current research available from the corresponding author on reasonable request.

The authors declare no conflict of interest.

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