

# Evaluation of empty palm fruit bunches as a dietary filler on the growth performance and digestive tract development of broiler chickens

*Tazkiya Qothrunnada Ashila* Fakh<sup>1</sup>, *Muhammad Ridla*<sup>2</sup>, *Sumiati*<sup>2</sup>, and *Nahrowi*<sup>2,3\*</sup>

<sup>1</sup>Graduate School of Nutrition and Feed Science, IPB University, Jalan Raya Dramaga, Bogor 16680, Indonesia

<sup>2</sup>Department of Nutrition and Feed Technology, IPB University, Jalan Raya Dramaga, Bogor 16680, Indonesia

<sup>3</sup>Center for Tropical Animal Studies, IPB University, Kampus IPB Baranangsiang, Jl Pajajaran, Bogor 16153, Indonesia

**Abstract.** Dietary fiber has been widely recognized for its beneficial effects on poultry performance, particularly in improving feed efficiency and maintaining digestive health in broiler chickens. However, the use of conventional fiber sources is often limited by high cost and dependence on imported materials. This research aimed to evaluate the potential of empty palm fruit bunches (EPFB), a by-product of the palm oil industry, as a locally available dietary fiber source and to assess its effects on growth performance and gastrointestinal development in broilers. A total of 200 Cobb day-old chicks were randomly assigned to four dietary treatments for 35 days: T0 (control diet without added fiber), T1 (control diet supplemented with 0.8% Arbocel®), T2 (control diet supplemented with 0.8% EPFB), and T3 (control diet supplemented 0.8% EPFB plus an enzyme cocktail). The inclusion of EPFB, either alone or in combination with enzymes, had no significant effects on body weight gain, feed intake, or feed conversion ratio. Likewise, the relative weight and length of the gastrointestinal tract did not differ significantly among treatments. These findings indicate that EPFB can be safely incorporated at the tested level as a locally available dietary fiber source without negative impacts on broiler performance.

## 1 Introduction

Dietary fiber consists of carbohydrate components that resist hydrolysis by endogenous digestive enzymes in the broiler gastrointestinal tract. Consequently, fiber has traditionally been regarded as an antinutritional component due to its low digestibility and limited contribution to dietary energy supply [1]. However, accumulating evidence from recent studies suggests that moderate levels of fiber inclusion may exert beneficial effects on broiler performance, particularly by improving feed efficiency, modulating gastrointestinal function, and enhancing digestive health [2-4]. In parallel, the demand for dietary fiber sources used as fillers in poultry diets is expected to increase. At present, commercial fiber sources are

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\* Corresponding author: [nahrowi@apps.ipb.ac.id](mailto:nahrowi@apps.ipb.ac.id)

predominantly imported, which places pressure on national foreign exchange reserves and increases dependency on external inputs, potentially affecting the long-term sustainability and resilience of the poultry industry.

Dietary fillersources are commonly obtained from widely available agro-industrial by-products that are cost-effective and do not interfere with human food utilization. Indonesia has substantial potential to supply locally sourced fiber-rich materials from its agro-industrial sector. Among these, empty palm fruit bunches (EPFB), a by-product of crude palm oil (CPO)processing, represent a promising yet underutilized source of dietary fiber with potential functional properties for broiler chickens. EPFB is rich in structural carbohydrate fractions, comprising approximately 28.71% crude fiber, 89.04% neutral detergent fiber (NDF), 42.82% acid detergent fiber (ADF), also 46.21% hemicellulose, along with a considerable lignin fraction (15.40%) [5, 6]. Severalstudieshave been carried out to evaluatethe impactof different fiber sources, includinggoat hulls, rice husks, soybean hulls, pea hulls, wheat bran, sunflower hulls, and other lignocellulosic materials, on broiler diets. Nevertheless,information regarding the inclusion of EPFB in broiler diets, especiallyits effects on feed intake, body weight gain, andgastrointestinal tract (weight and length) development, remains limited. Accordingly, this research was conducted to assess the effects of EPFB inclusion on growth performance and gastrointestinal tract development in broiler chickens,andto evaluate its suitability as a fiber source in broiler diets.

## 2 Research methods

### 2.1 Empty Palm Fruit Bunches (EPFB) preparation

Fresh EPFB were gained from the Palm Oil Processing Unit (UP3), Jonggol, IPB University. The EPFB was initially coarsely chopped using a mechanical chopper and subsequently sun-dried until a constant weight was achieved. The dried material was ground using a hammer mill and subsequently passed through a sieve to obtain a uniform particle size, producing EPFB fiber meal. The EPFB meal was analyzed to determine its physical and chemical characteristics before dietary incorporation.

### 2.2 Diet and animal preparation

The fiber sources evaluated in this study were a commercial purified cellulose product (Arbocel®; JRS Pharma, Germany) and empty palm fruit bunches (EPFB). The characteristics of the fiber sources used in this study are presented in Table 1. To exceed the nutrient needs of broiler chickens as suggested by Cobb-Vantress guidelines (Table 2), the basal (control) diet was formulated. Experimental diets were provided according to the feeding phase: 1–14 days of age (a starter diet) in crumble form and 15–35 days of age (a finisher diet) in pellet form.

The Cobb broiler strain's 200-day-old chicks (DOC) were randomly allocated into 4 treatments and 5 replicates, each containing 10 birds, and reared for 35 days. The dietary treatments included: T0 (control diet), T1 (control diet supplemented with 0.8% Arbocel®), T2 (control diet supplemented with 0.8% EPFB), and T3 (control diet supplemented consist 0.8% EPFB plus a cocktail of exogenous enzymes). The enzyme used was a commercial cocktail enzyme produced by Wuhan Sunhy Biology Co., Ltd., containing Xylanase 40000 U/g,  $\beta$ -Glucanase 3000 U/g,  $\beta$ -Mannanase 100 U/g, Cellulase 750 U/g, Pectinase 2000 U/g, Protease 25,000 U/g, and Amylase 3000 U/g. At a level of 0.02% of the total feed weight, the enzyme was supplemented. Birds were presented with *ad libitum* access to feed and water throughout the trial.

**Table 1.** Chemical compositions and physical properties of fiber sources

Parameter	Arbocel	EPFB
Crude Fiber (%)	44.71	22.14
Neutral Detergent Fiber (%)	85.18	54.66
Acid Detergent Fiber (%)	63.38	35.61
Hemicellulose (%)	21.80	19.05
Cellulose (%)	42.17	24.34
NDF/ADF Ratio	1.34	1.53
Bulk Density (kg m <sup>-3</sup> )	418.8	762,00
Tapped Density (kg m <sup>-3</sup> )	676.2	1051.4

EPFB = Empty palm fruit bunches

### 2.3 Growth performance and gastrointestinal tract evaluation

Body weight and feed intake were measured on a cage basis at weekly intervals throughout the trial period (days 1-35). Based on these data, feed intake (FI), average daily feed intake (ADFI), body weight (BW), body weight gain (BWG), average daily gain (ADG), and feed conversion ratio (FCR) were calculated. On day 35, one bird from each cage was chosen at random, weighed, and also slaughtered by severing the jugular vein in accordance with applicable ethics. The gastrointestinal tract (GIT) with no digestive content was also removed and weighed individually. Empty GIT weights were conveyed as a percentage (%) of kg live BW.

**Table 2.** Composition of ingredients and nutritional value of experimental diets.

Raw material	Starter diet				Finisher diet			
	T0	T1	T2	T3	T0	T1	T2	T3
Ingredient (%)								
Corn	57	56.55	56.55	56.55	59.46	58.99	58.99	58.99
Rice bran	4.4	4.37	4.37	4.37	5.5	5.46	5.46	5.46
CGM	0	0	0	0	2	1.98	1.98	1.98
SBM	24.5	24.31	24.31	24.31	21.22	21.05	21.05	21.05
MBM	7	6.94	6.94	6.94	3.5	3.47	3.47	3.47
PKM	3	2.98	2.98	2.98	3	2.98	2.98	2.98
Oil	1	0.99	0.99	0.99	2.5	2.48	2.48	2.48
DCP	1	0.99	0.99	0.99	1	0.99	0.99	0.99
CaCO <sub>3</sub>	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
NaCl	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Premix	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
L-Lysine	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
DL-Methionine	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
Tryptophan	0.3	0.3	0.3	0.3	0.12	0.12	0.12	0.12

**Table 2.** Composition of ingredients and nutritional value of experimental diets (continue).

Raw material	Starter diet				Finisher diet			
	T0	T1	T2	T3	T0	T1	T2	T3
Ingredient (%)								
Arbocel®	0	0.8	0	0	0	0.8	0	0
EPFB	0	0	0.8	0.8	0	0	0.8	0.8
Total	100	100	100	100	100	100	100	100
Nutrient content (%as fed basis)								
DM (%)	88.42	88.48	88.49	88.49	88.31	88.33	88.36	88.36
CP (%)	21.24	21.07	21.15	21.15	19.47	19.31	19.38	19.38
EE (%)	4.55	4.53	4.53	4.53	5.8	5.76	5.77	5.77
CF (%)	2.47	2.81	2.63	2.63	2.58	2.91	2.73	2.73
ME (Kkalkg <sup>-1</sup> )	2933	2910	2910	2910	3062	3037	3037	3037
NDF(%)	13.49	14.07	13.82	13.82	13.97	14.54	14.3	14.3
ADF(%)	5.11	5.58	5.35	5.35	5.19	5.66	5.44	5.44
Hem (%)	8.38	8.49	8.47	8.47	8.78	8.88	8.86	8.86
Ca (%)	1.05	1.04	1.04	1.04	0.77	0.76	0.76	0.76
P (%)	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48

T0 (control diet without added fiber); T1 (control diet supplemented consist 0.8% Arbocel®); T2 (control diet supplemented consist 0.8% EPFB); T3 (control diet supplemented consist 0.8% EPFB plus an enzyme cocktail); corn gluten meal (CGM); soybean meal (SBM); meat bone meal (MBM); palm kernel meal (PKM); DCP (dicalcium phosphate); CaCO<sub>3</sub>(calcium carbonate); NaCL (natrium chloride); Ca (calcium); Premix (Vit A 12,000,000 IU; Vit D<sub>3</sub> 2,000,000 IU; Vit E 8,000 IU; Vit K<sub>3</sub> 2,000 mg; Vit B<sub>1</sub> 2000 mg; Vit B<sub>2</sub> 5,000 mg; Vit B<sub>6</sub> 500 mg; Vit B<sub>12</sub> 12,000 µg; Vit C 25,000 mg; Calcium D-pantothenate 6,000 mg; Niacin 40,000 mg; Cholin chloride 10,000 mg; Methionine 30,000 mg; Lysine 30,000 mg; Manganese 120,000 mg; Iron 20,000 mg; Iodine 200 mg; Zinc 100,000 mg; Cobalt 200 mg; Copper 4,000 mg; Santoquin (Antioxidant) 10,000 mg; Growth promoter 1,300,000 mg).

### 2.3 Data analysis

The study was conducted using a completely randomized design (CRD) with 4 treatments and 5 replicates, each replicate consisting of 10 broiler chickens. For the growth performance parameter, the cage served as the experimental unit, whereas individual birds were considered the experimental unit for organ weight measurements. Data on growth performance and gastrointestinal tract (GIT) weights were analyzed using the General Linear Model (GLM) procedure in statistical software (SPSS). Duncan’s multiple range test was also used to determine whether differences were statistically significant at  $P < 0.05$ .

## 3 Results and discussion

### 3.1 Broiler performance

Based on the results, there is no significant effect on the inclusion of fiber in broiler feed ( $P > 0.05$ ) on ADFI, ADG, and FCR. Feed intake in this study varied from 63.03 to 67.42 g/b/d, with the highest intake in treatment T3 ( $67.42 \pm 1.08$  g/bird/day) and the lowest in T1 ( $63.03 \pm 2.70$  g/bird/day). The decreased feed intake in T1 and T2 may be associated with the higher

inclusion of dietary fiber in the respective diets (Table 2). Feed with high fiber content tends to have low energy density, thereby reducing feed intake [7]. The fibersourceandits inclusion levelinfluence feed intake [8].

The effects of fiber source incorporation on broiler growth performance over the 35-day trial period are shown in Table 3. There is no significant treatment effect ( $P > 0.05$ ) detected among treatments for BW, BWG, ADG, FI, ADFI, or FCR. These results indicate that the inclusion of 0.8% fiber, either from Arbocel® or EPFB, with or without enzyme addition, did not result in a significant impact on broiler growth performance.

**Table 3.** Broiler performance at 35 days of age

Parameters	Treatments				P-Value
	T0	T1	T2	T3	
BW (g/bird)	1479.25 ± 83.78	1474.50 ± 51.93	1474.75 ± 58.96	1552.35 ± 14.29	0.213
BWG g/bird)	1439.63 ± 83.28	1435.38 ± 51.43	1435.00 ± 59.18	1513.90 ± 13.36	0.200
ADG (g/bird/d)	41.13 ± 2.38	41.01 ± 1.47	41.00 ± 1.69	43.26 ± 0.38	0.200
FI (g/bird)	2277.00 ± 135.80	2205.88 ± 94.32	2216.25 ± 56.76	2359.50 ± 37.98	0.110
ADFI (g/bird/d)	65.06 ± 3.88	63.03 ± 2.70	63.32 ± 1.62	67.42 ± 1.08	0.110
FCR	1.58 ± 0.01	1.59 ± 0.08	1.57 ± 0.04	1.59 ± 0.05	0.899

BW (body weight); BWG (body weight gain); ADG (average daily gain); FI (feed intake); ADFI (average daily feed intake); FCR (feed conversion ratio); T0 (control diet without added fiber); T1 (control diet supplemented consist 0.8% Arbocel®); T2 (control diet supplemented consist 0.8% EPFB); T3 (control diet supplemented consist 0.8% EPFB plus an enzyme cocktail).

Although not statistically significant, broilers fed the EPFB diet supplemented with a cocktail of exogenous enzymes (T3) exhibited numerically higher BW, BWG, and ADG compared with the other treatments. The ADG in T3 (43.26 g/bird/day) was approximately 5% advance than that of the control group (41.13 g/bird/day). This numerical improvement may be associated with the action of enzyme cocktails in hydrolyzing complex lignocellulosic components into simpler fractions, thereby enhancing nutrient availability and energy utilization. Previous studies have reported that exogenous enzymes can improve the digestibility of starch and non-starch polysaccharides, leading to more efficient nutrient use in broiler diets [9, 10].

The feed conversion ratio ranged from 1.57 to 1.59 across treatments, indicating comparable feed efficiency among dietary groups. These values are lower than those stated by Nursiam (1.89–1.98) but higher than those reported by Mateos (1.32–1.38) [3, 11], reflecting differences in diet composition, fiber type, inclusion level, and broiler strain. The lowest FCR value was observed in broilers fed the EPFB-based diet without enzyme supplementation (T2), suggesting that EPFB can be utilized effectively as a dietary fiber source without compromising feed efficiency. Overall, the findings demonstrate that a 0.8% inclusion level of EPFB is well tolerated by broiler chickens and can maintain growth performance comparable to that of conventional purified fiber sources.

### 3.2 Gastrointestinal Tract (GIT) development

Table 4 presented the dietary fiber inclusion significantly affected ( $P < 0.05$ ) the relative proventriculus weight. In the control group (T0; 0.58%), followed by T3 (0.43%), T1 (0.41%), and T2 (0.40%), the highest relative proventriculus weight was observed. The supplementation of Arbocel® or EPFB, with or without an enzyme cocktail, was associated with a decrease in proventriculus weight relative to the control diet. The proventriculus, located in the upper gastrointestinal tract, functions as the primary site of chemical digestion and regulates the passage of digesta into the gizzard [12]. The inclusion of fiber at 0.8% did

not appear to increase the functional workload of the proventriculus, as reflected by the reduced organ weight. Importantly, the relative proventriculus weights observed across treatments remained within the normal physiological range (0.40–0.54%) for broiler chickens [12].

In contrast, experimental diets did not significantly affect gizzard weight ( $P > 0.05$ ). From 1.25% to 1.45%, the relative gizzard weight ranged, which is within the reported normal range of 1.30–2.30% [12]. Although not statistically significant, diets containing Arbocel® or EPFB tended to increase gizzard weight compared with the control. The gizzard functions as the primary mechanical digestive organ, and increases in its relative weight are often associated with enhanced grinding activity, which may improve nutrient digestibility [13]. The primary insoluble fiber found in EPFB may increase the needs of mechanical digestion, hence stimulating gizzard activity. Increased gizzard activity is associated with enhanced gastrointestinal reflux and pancreatic enzyme secretion. Structural insoluble fiber may also influence feed passage rate, potentially improving nutrient digestibility and growth performance, although coarsely ground insoluble fiber is generally reported to accelerate digesta passage [3, 7]. Such adaptations are commonly influenced by dietary fiber level and particle size, as coarser and more fibrous materials stimulate greater gizzard development and activity [14].

**Table 4.** Gastrointestinal tract development in 35-day-old broilers

Parameters	Treatments				P-Value
	T0	T1	T2	T3	
Relative GIT weight (%)					
Proventriculus	0.58 ± 0.02 <sup>a</sup>	0.41 ± 0.00 <sup>c</sup>	0.40 ± 0.01 <sup>c</sup>	0.47 ± 0.01 <sup>b</sup>	0.000
Gizzard	1.25 ± 0.14	1.28 ± 0.12	1.36 ± 0.12	1.45 ± 0.04	0.212
Small intestine	2.67 ± 0.29	2.60 ± 0.06	2.60 ± 0.24	2.65 ± 0.32	0.982
Caecum	0.24 ± 0.06	0.23 ± 0.04	0.23 ± 0.05	0.25 ± 0.05	0.932
Relative GIT length (cm/kg BB)					
Small intestine	14.20 ± 0.86	13.08 ± 0.68	14.25 ± 2.12	14.09 ± 1.78	0.761
Caecum	1.02 ± 0.05 <sup>b</sup>	1.46 ± 0.18 <sup>a</sup>	1.15 ± 0.10 <sup>b</sup>	1.12 ± 0.05 <sup>b</sup>	0.004

In the recent study, dietary fiber inclusion did not show a significant effect ( $P > 0.05$ ) on the relative weight or length of the small intestine (SI). As the principal site of digestion and nutrient uptake in broiler chickens [15], its structural development is strongly linked to nutrient digestibility. Variations in fiber type and inclusion level may influence intestinal physiology by altering digesta and passage rate. Soluble fibers generally increase digesta viscosity and may slow intestinal transit, whereas insoluble fibers, such as cellulose and lignin, tend to reduce viscosity and accelerate digesta passage. The relatively low fiber inclusion level (0.8%) applied in the present study was likely insufficient to induce measurable changes in small intestinal development.

In contrast, relative cecal length differed significantly among treatments ( $P < 0.05$ ), although relative cecal weight was not influenced ( $P > 0.05$ ). The cecum serves as the primary site of microbial fermentation, where undigested fibrous components escaping small intestinal digestion are metabolized. Both fiber type and inclusion level are key determinants of cecal fermentative activity [12]. In this study, relative cecal weight ranged from 0.23% to 0.25%, suggesting that the 0.8% fiber inclusion was inadequate to stimulate substantial changes in fermentative capacity. However, fiber supplementation tended to increase cecal

length, with T1 exhibiting the longest cecum. This response could be attributed to the physicochemical characteristics of Arbocel®, which contains a high proportion of purified cellulose (42.17%), compared with EPFB, which is characterized by a more complex lignocellulosic structure.

## 4 Conclusion

The inclusion of 0.8% empty palm fruit bunches (EPFB), either alone or in combination with exogenous enzymes, did not adversely affect growth performance or gastrointestinal development in broiler chickens. These results suggest that EPFB can be safely incorporated at this inclusion level without negative effects and may serve as a locally available dietary fiber source comparable to commercial fiber products. Further research is required to evaluate its effects at different inclusion levels.

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