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Carcass Yield and Visceral Organs of Broiler Chickens Fed Palm Kernel Meal or *Aspergillus wentii* TISTR 3075 Fermented Palm Kernel Meal

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Abstract

The objective of the current study was to investigate the effect of palm kernel meal (PKM) and *Aspergillus wentii* TISTR 3075 fermented PKM (FPKM) at various levels on carcass yield and visceral organs of broiler chickens. A 2 × 4 factorial experiment in a completely randomized design with one control was applied. The first factor was two kinds of PKM and the second factor consisted of PKM or FPKM 10, 20, 30 and 40 % in the rations. The yield of hot carcass carried out in broilers showed no benefit in using the fermented substrate as a ration component in the broiler feed. Quadratic responses were found in relative liver weights of both broilers fed various levels of PKM and FPKM ($P = 0.062$ and $P = 0.002$, respectively). The relative heart weight was affected linearly by increasing levels of FPKM ($P = 0.009$). The spleen was little affected by PKM, whereas FPKM seemed linearly affected ($P = 0.078$) as FPKM levels were increased from 10 to 40 %. The relative gizzard weight for broilers fed with FPKM was linear with increased levels of FPKM ($P = 0.043$); but the trend for broilers fed with PKM was not significant ($P > 0.05$). Abdominal fat pad linearly decreased with increasing levels of PKM ($P = 0.032$) or FPKM ($P = 0.023$). From this experiment, we conclude that fermented PKM with *A. wentii* TISTR 3075 had no adverse effect on carcass yield and relative weight of visceral organs of broiler chickens.

Keywords: Broiler chicken, fermented palm kernel meal, carcass, visceral organ, abdominal fat pad

Introduction

Palm kernel meal (PKM) or palm kernel cake (PKC) is a by-product from the African palm (*Elaeis guinensis*) oil industry. It can be classified as an energy feed because the protein content ranges from 16 - 18 % [1]. More than 60 % of the PKM includes a cell wall component. The non-starch polysaccharides (NSPs) in the PKM cell wall are composed mainly of insoluble mannose-based polysaccharide (mannan) [2-5]. Duad *et al.* [4] reported that the PKM cell wall was comprised 58 % mannan, 12 % cellulose and 4 % xylan. The high amount of NSPs has limited the use of PKM as a component in feeds for monogastric animals, poultry and pigs. Fermented PKM with mannanase producing fungus might improve the quality of PKM as a poultry diet.

Using PKM as a substrate, Sae-lee [6] examined the maximum NSPs degradation in *Aspergillus wentii* TISTR 3075 fermentation, by increasing mannanase, cellulase and xylanase activities, compared to *A. niger*, *A. oryzae*, *Trichoderma reesei* TISTR 3080 and *Penicillium sp*. Muangkeow and Chinajariyawong [7] reported a decrease in cell wall content from 77.56 % in PKM to 73.32 % when fermented with *A. wentii* TISTR 3075 (FPKM) while protein content increased from 16.99 to 21.36 %. They also found that sulphur containing amino acids (cysteine and methionine) and lysine were limiting amino acids in PKM and FPKM, but arginine content was high. The apparent metabolizable energy (AME on DM basis) of PKM and FPKM were 2,201.83 and 2,080.26 kcal/kg, respectively. The nitrogen-corrected apparent metabolizable energy (AME_n), true metabolizable energy (TME) and nitrogen-corrected true metabolizable energy (TME_n) of PKM (DM basis: 2,202.05, 2,958.21 and 2,957.86 kcal/kg, respectively) were slightly higher than FPKM (DM basis: 2,080.33, 2,843.01 and 2,842.50 kcal/kg, respectively). *A. wentii* might use up the nitrogen-free extract (NFE) in PKM as an energy source during the fermenting process, resulting in low metabolizable energy of FPKM when compared with PKM. Also our unpublished data showed that broilers performance decreases linearly with increasing levels of PKM in the diets from 10 to 40 %, while those fed with FPKM showed a quadratic increase of 20 % before slowly declining.

PKC and PKM affected some carcass characteristics of the test animals studied. Maliwon [8] found no significant difference among treatments for the percentage of hot carcass, thigh and drumstick of broilers fed with diets containing 0 (control), 20, 30 and 40 % PKC formulated based on either total amino acids or available amino acids. The percentage of abdominal fat of broilers fed the control diet on available amino acid basis was lower than those fed different levels of PKC diets, but was not significantly different from the broilers fed the control diet on total amino acids and 20 % PKC on available amino acid basis. Edible visceral organs of chicken increased and abdominal fat decreased when broilers were fed 40 % PKM [9]. Fat in the meat was significantly reduced as PKM was increased from 0 - 20 % PKM during starter period and 0 - 30 % PKM during finisher period [9]. The carcass percentage of broilers fed the 30 % PKM diet was slightly lower than those fed the control diet. Broilers fed the control diet had significantly higher abdominal fat than those fed 30 % PKM [10]. Other than broiler, red tilapia raised on PKC treated with *T. longibrachiatum* (TL-PKC) from 0 to 40 % in rations, had body lipids decreased as TL-PKC levels increased while the carcass moisture increased. At 30 and 40 % both had the lowest lipid content, which was much lower than the control [11].

The objective of this study was to assess the effect of PKM and FPKM at various levels on carcass yield and visceral organs of broiler chickens.

Materials and methods

Birds and housing

The experiment was conducted in floor pens with wood shavings, 120 × 100 cm in size (density of 1,000 cm^2 per bird), in an environmentally controlled house. Four hundred thirty two one-day-old straight run Ross-308 broiler chickens were randomly divided into 36 experimental units with 12 chickens each. A 2 × 4 factorial experiment in a completely randomized design with one control treatment was used. The first factor was two kinds of palm kernel meal, PKM and FPKM, and the second factor was the inclusion levels of 10, 20, 30 and 40 % in the rations. The birds were kept under standard management conditions. Feed and water were provided *ad libitum* throughout the experimental period.

Experimental diets

The compositions of the experimental diets with two-phase feeding (starter, 0 - 3 wk; finisher, 3 - 6 wk) are shown in **Tables 1** and **2**, respectively. All nutrient contents met NRC recommendations [12]. FPKM preparation, chemical compositions and nutritive values of PKM and FPKM were those previously reported by Muangkeow and Chinajariyawong [7].

Table 1 Composition of experimental diets (0 - 3 wk).

Item, %	Control	Palm kernel meal				*Aspergillus wentii* fermented PKM			
		10	20	30	40	10	20	30	40
Ingredients									
Yellow corn	61.18	51.07	41.00	30.73	20.72	51.92	42.66	33.27	24.02
Palm kernel meal	0.00	10.00	20.00	30.00	40.00				
A. wentii fermented PKM	0.00					10.00	20.00	30.00	40.00
Soybean oil meal 45 % CP	25.15	23.35	21.41	19.75	17.78	22.38	19.60	16.90	14.15
Fish meal 62 % CP	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Palm olein oil	1.60	3.57	5.50	7.45	9.40	3.60	5.60	7.65	9.70
Oyster shell	1.00	0.97	0.95	0.92	0.92	0.98	0.96	0.93	0.92
Monocalcium phosphate 21 % P	0.20	0.17	0.16	0.13	0.13	0.18	0.17	0.14	0.10
Common salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
DL-methionine	0.20	0.16	0.16	0.15	0.14	0.18	0.17	0.15	0.15
L-lysine	0.00	0.07	0.12	0.17	0.21	0.06	0.14	0.19	0.25
Coccidiostat (Salinomycin Na)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Vitamin-mineral premix[1/]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Calculated composition									
Crude protein	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
AME (kcal/kg)	3,080	3,080	3,080	3,080	3,080	3,080	3,080	3,080	3,080
Crude fiber	2.40	3.80	5.21	6.62	8.02	3.99	5.57	7.16	8.75
Calcium	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Available phosphorus	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Lysine	1.27	1.28	1.28	1.28	1.28	1.27	1.28	1.28	1.28
Methionine	0.57	0.57	0.58	0.57	0.57	0.59	0.58	0.57	0.57
Methionine + cysteine	1.01	0.99	0.99	0.96	0.95	1.01	0.99	0.96	0.95
Threonine	0.89	0.88	0.87	0.86	0.84	0.88	0.87	0.85	0.85
Tryptophan	0.24	0.24	0.23	0.23	0.22	0.22	0.20	0.21	0.20
Arginine	1.38	1.48	1.57	1.68	1.77	1.43	1.48	1.54	1.59

[1/]Supplied per kilogram of diets : vitamin A, 19,200 IU; vitamin D_3, 3,840 IU; vitamin E, 8 IU; vitamin K_3, 3.2 mg; thiamin, 2.4 mg; riboflavin, 6.4 mg; vitamin B_{12}, 0.0024 mg; nicotinic acid, 2.4 mg; folic acid, 0.8 mg; biotin, 0.16 mg; pantothenic acid, 16 mg; manganese, 96 mg; zinc 160 mg; iron, 128 mg; copper, 9.6 mg; selenium, 0.24 mg.

Table 2 Composition of experimental diets (3 - 6 wk).

Item, %	Control	Palm kernel meal				*Aspergillus wentii* fermented PKM			
		10	20	30	40	10	20	30	40
Ingredients									
Yellow corn	50.64	55.36	45.34	35.28	25.25	56.26	47.05	37.54	28.34
Defatted rice bran	12.00								
Palm kernel meal	0.00	10.00	20.00	30.00	4.000				
A. wentii fermented PKM	0.00					10.00	20.00	30.00	40.00
Soybean oil meal 45 % CP	22.03	20.91	19.06	17.20	15.33	19.99	17.24	14.53	11.79
Fish meal 62 % CP	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Palm olein oil	6.55	4.90	6.78	8.70	10.60	4.90	6.85	9.05	11.00
Oyster shell	1.27	1.24	1.20	1.19	1.16	1.24	1.22	1.20	1.19
Monocalcium phosphate 21 % P	0.24	0.25	0.24	0.20	0.18	0.26	0.24	0.22	0.18
Common salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
DL-methionine	0.12	0.12	0.11	0.11	0.10	0.12	0.11	0.11	0.10
L-lysine	0.22	0.27	0.32	0.37	0.43	0.28	0.34	0.40	0.45
Coccidiostat (Salinomycin Na)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Vitamin-mineral premix[1/]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Calculated composition									
Crude protein	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
AME (kcal/kg)	3,170	3,170	3,170	3,170	3,170	3,170	3,170	3,170	3,170
Crude fiber	3.46	3.78	5.18	6.59	8.00	3.96	5.55	7.13	8.73
Calcium	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Available phosphorus	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Lysine	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
Methionine	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Methionine + cysteine	0.84	0.83	0.81	0.80	0.79	0.82	0.80	0.79	0.77
Threonine	0.76	0.74	0.73	0.72	0.70	0.74	0.73	0.72	0.71
Tryptophan	0.22	0.20	0.20	0.19	0.19	0.20	0.19	0.18	0.17
Arginine	1.22	1.26	1.36	1.46	1.55	1.22	1.27	1.32	1.38

[1/]Supplied per kilogram of diets : vitamin A, 19,200 IU; vitamin D_3, 3,840 IU; vitamin E, 8 IU; vitamin K_3, 3.2 mg; thiamin, 2.4 mg; riboflavin, 6.4 mg; vitamin B_{12}, 0.0024 mg; nicotinic acid, 2.4 mg; folic acid, 0.8 mg; biotin, 0.16 mg; pantothenic acid, 16 mg; manganese, 96 mg; zinc 160 mg; iron, 128 mg; copper, 9.6 mg; selenium, 0.24 mg.

Data collection

At 42 days old, 2 male birds from each replicate (with no visible abnormalities) were randomly selected for eviscerated carcass yield. Birds were starved for 12 h before processing. Data on carcass yield (including skin), heart, gizzard, liver, spleen, and abdominal fat pad (calculated as % of live body weight, live BW) were recorded.

Statistical analyses

Prior to analyses, data expressed as a percentage of carcass weight were arc sine and square root transformed to meet the assumptions of analysis of variance. Analysis of covariance was performed by using live body weight as a covariate factor. Where significant differences among treatments were obtained, comparisons among means were performed by Tukey's Honestly. Orthogonal contrasts were performed when comparison with control and kinds of PKM and orthogonal polynomial contrasts were applied to test the linear or quadratic nature of the response to incremental concentrations in both PKM and FPKM [13,14].

Results

The interactions between kinds of palm kernel meal and levels of PKM or FPKM inclusion in the diets on all parameters were not detected ($P > 0.05$). Dressing percentage of birds fed diets containing PKM or FPKM was not significantly different ($P > 0.05$) when compared with those birds fed the control diet. Feeding PKM or FPKM had no effect on the dressing percentage ($P > 0.05$) (**Tables 3** and **4**).

The relative weight of the gizzard and spleen of birds fed a diet containing PKM was not significantly different ($P = 0.398$ and 0.066, respectively) when compared with birds fed the control diet. However, the relative weight of the liver was lower ($P = 0.032$) than those of the control but relative heart weights were significant higher than the control ($P = 0.012$). The abdominal fat pad of the birds fed diets containing PKM or FPKM were also significantly lower ($P = 0.016$) than those fed the control diet.

Considering the responses to various levels of PKM or FPKM supplementation to the diets, the relative liver weight of broilers fed with PKM seemed to have a quadratic effect ($P = 0.062$) (**Figure 1 (a)**). Interestingly, the same response was also found in FPKM levels but statistical significance ($P = 0.002$) was detected with an equation of: Liver = 1.8339 – 0.031FPKM + $0.008696FPKM^2$, ($r^2 = 0.4667$) as shown in **Figure 1 (b)**.

The relative heart weight of broilers fed FPKM increased linearly ($P = 0.009$) with a regression equation of: Heart = 0.406 + 0.003675FPKM, ($r^2 = 0.6678$) as shown in **Figure 2**. A non-significant response was observed in birds fed PKM diets.

The relative spleen weight was little affected by PKM, whereas tended to increase linearly ($P = 0.078$) when FPKM increased from 10 to 40 % (**Figure 3**) generating the regression equation: Spleen = 0.055 + 0.00277FPKM, ($r^2 = 0.50$).

The relative gizzard weight of broilers fed FPKM increased linearly ($P = 0.043$). The equation shown in **Figure 4** was Gizzard = 1.382 + 0.019425FPKM, ($r^2 = 0.73$). However, the relationship for broilers fed PKM was not significant ($P > 0.05$).

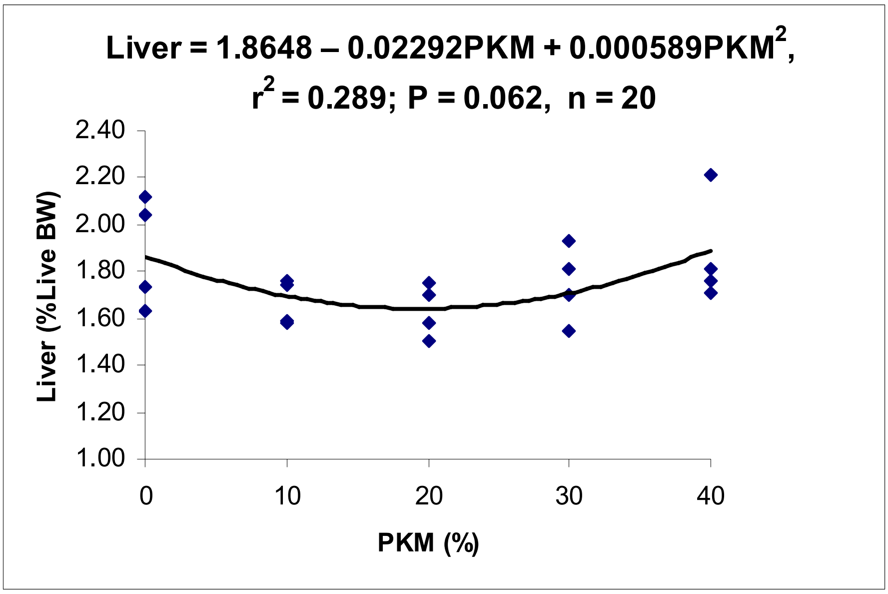
Figure 5 showed relationships between the abdominal fat pad and levels of PKM and FPKM supplementation, the relative abdominal fat pad weight decreased linearly with PKM ($P = 0.032$) or increased with FPKM ($P = 0.023$) from 0 to 40 % generated the equations: Abdominal fat pad = 2.302 - 0.04075PKM ($r^2 = 0.78$) (**Figure 5 (a)**) and Abdominal fat pad = 2.1395 – 0.0324FPKM, ($r^2 = 0.68$) (**Figure 5 (b)**); respectively.

Table 3 Dressing carcass weight and percentage of dressed carcass yield, visceral organs and abdominal fat pad of broilers fed various levels of palm kernel meal (PKM) or *Aspergillus wentii* TISTR 3075 fermented palm kernel meal (FPKM).

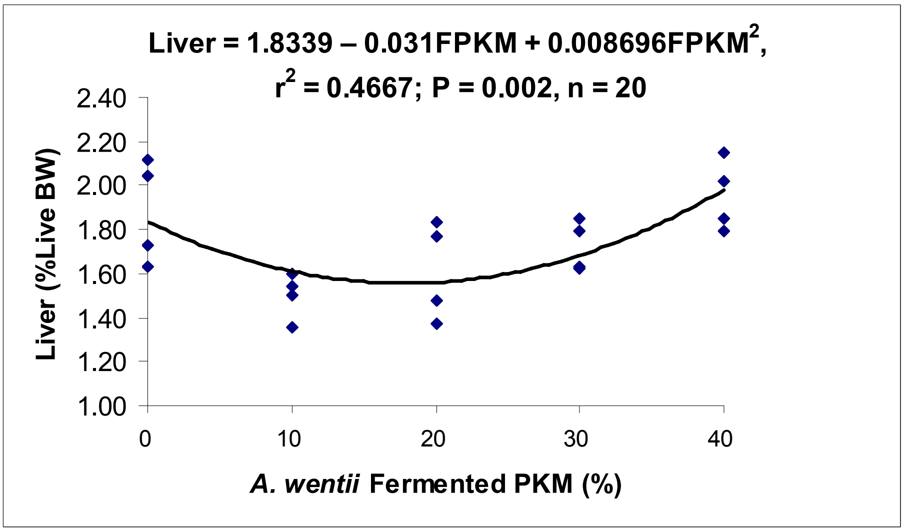
Traits	Control	Palm kernel meal				*A. wentii* fermented palm kernel meal				CV (%)
		10	20	30	40	10	20	30	40	
Processing live wt. (kg.)	2.63	2.40	2.46	2.25	1.96	2.21	2.38	2.11	1.87	
Dressing wt. (kg.)	2.16	1.98	2.03	1.84	1.61	1.81	1.96	1.69	1.51	
Dressing (% of live BW)	69.95	70.27	70.43	69.75	70.12	69.71	70.14	68.10	68.49	1.88
Liver wt. (g)	49.50	39.89	40.34	39.36	36.82	33.37	38.28	36.20	36.56	
Liver (% of live BW)	1.88	1.66	1.63	1.75	1.87	1.50	1.61	1.72	1.95	4.77
Gizzard wt (g)	37.24	37.08	35.12	42.89	43.01	26.27	38.88	39.72	42.43	
Gizzard (% of live BW)	1.41	1.54	1.42	1.91	2.15	1.64	1.65	1.89	2.26	4.30
Heart wt (g)	11.41	13.77	12.56	11.62	11.23	9.70	10.88	10.89	10.62	
Heart (% of live BW)	0.42	0.57	0.51	0.52	0.57	0.44	0.46	0.52	0.57	4.04
Spleen wt. (g)	4.66	3.31	3.24	3.85	2.96	8.09	2.51	2.41	3.40	
Spleen (% of live BW)	0.17	0.14	0.13	0.12	0.16	0.09	0.11	0.11	0.18	14.59
Abdominal fat pad wt. (g)	61.65	42.24	40.09	24.02	12.91	35.62	36.77	21.01	19.11	
Abdominal fat pad (% of live BW)	2.34	1.76	1.61	1.06	0.66	1.57	1.54	0.97	1.03	11.67

Table 4 P-value of orthogonal contrast and orthogonal polynomial relative weight of hot dressed carcass yield, visceral organs and abdominal fat pad of broilers fed various levels of palm kernel meal (PKM) or *Aspergillus wentii* TISTR 3075 fermented palm kernel meal (FPKM).

Traits	Contrast		PKM-Orthogonal polynomial			FPKM- Orthogonal polynomial		
	Control vs others	PKM vs FPKM	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic
Dressing (% of live BW)	0.881	0.204	0.755	0.956	0.562	0.142	0.655	0.812
Liver (% of live BW)	0.032	0.080	0.792	0.062	0.491	0.731	0.002	0.087
Gizzard (%live BW)	0.398	0.455	0.292	0.137	0.289	0.043	0.161	0.875
Heart (% of live BW)	0.012	0.000	0.127	0.158	-	0.009	0.185	0.700
Spleen (% of live BW)	0.066	0.048	0.503	0.258	0.930	0.078	0.465	0.389
Abdominal fat pad (% of live BW)	0.016	0.045	0.032	0.630	0.866	0.023	0.109	0.567



(a)



(b)

Figure 1 Relationships between levels of palm kernel meal (PKM) (a) and *Aspergillus wentii* TISTR 3075 fermented palm kernel meal (FPKM) (b) in rations on relative liver weight of broilers.

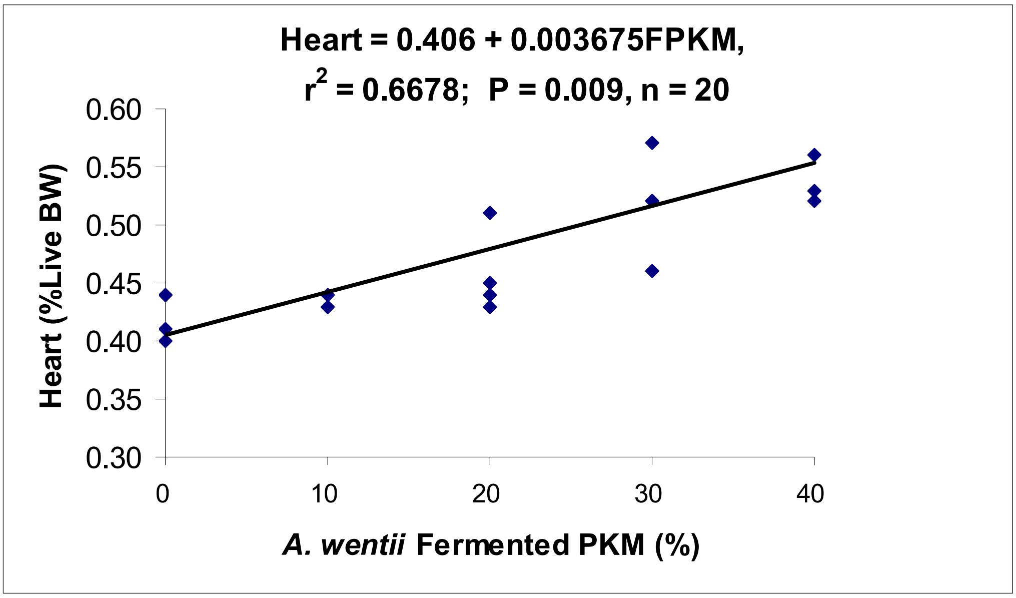


Figure 2 Relationships between levels of *Aspergillus wentii* TISTR 3075 fermented palm kernel meal (FPKM) in rations on relative heart weight of broilers.

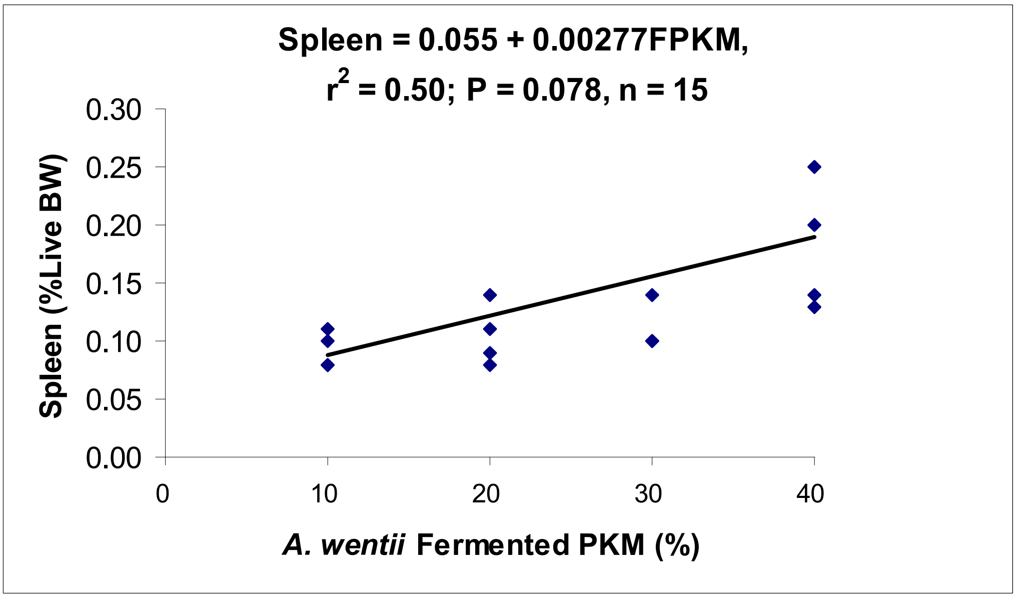


Figure 3 Relationships between levels of *Aspergillus wentii* TISTR 3075 fermented palm kernel meal (FPKM) in rations on relative spleen weight of broilers.

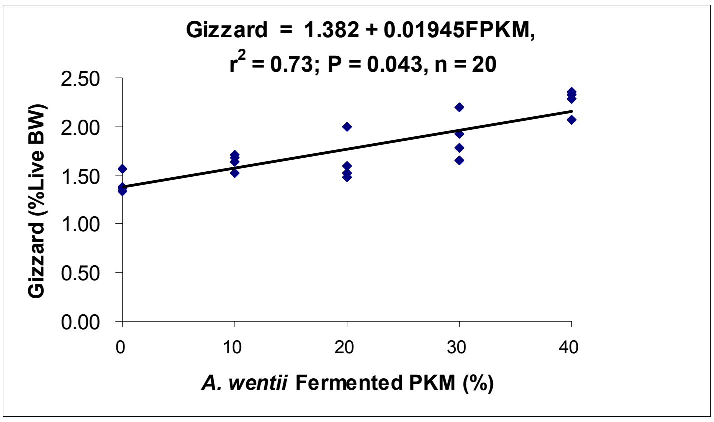
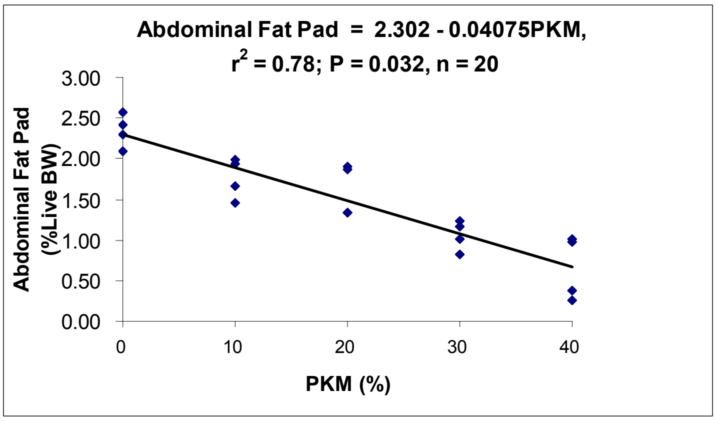
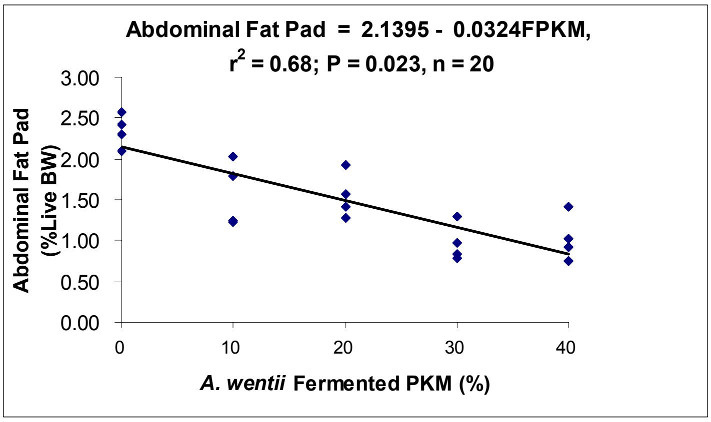


Figure 4 Relationships between levels of *Aspergillus wentii* TISTR 3075 fermented palm kernel meal (FPKM) in rations on relative gizzard weight of broilers.



(a)



(b)

Figure 5 Relationships between levels of palm kernel meal (PKM) (a) and *Aspergillus wentii* TISTR 3075 fermented palm kernel meal (FPKM) (b) in rations on the abdominal fat pad of broilers.

Discussion

The estimated metabolizable energy intake per kilogram live BW of birds fed the control diet was 5,781.59 kcal, birds fed diets containing PKM were 4,893.42, 5,376.85, 5,527.63 and 6,336.21 kcal at levels of PKM 10, 20, 30, and 40 % in rations, respectively. Whereas birds fed diets containing FPKM were 5,987.67, 5,118.58, 5,996.17 and 5,814.58 kcal for levels of 10, 20, 30 and 40 %, respectively. The results of apparent metabolizable energy intake showed that birds fed a diet containing 40 % PKM and birds fed diet containing 30 and 40 % FPKM were less efficient than those birds fed the control diet (unpublished data). Normally, the best metabolizable energy intake rate per each kilogram of live weight ranged from 5,750 to 6,000 kcal/kg [15]. However, in theory, birds adjust their feed intake to obtain a constant energy intake [16].

The poor performance obtained when high levels of PKM or FPKM were used was probably due to the high concentration of non-starch polysaccharides (NSPs) in PKM. Estimated crude fiber intake throughout 6 wk feeding of birds fed a control diet was 134.13 g, birds fed diets containing PKM 10, 20, 30 and 40 % were 167.44, 234.03, 289.04 and 333.66 g, respectively, while those fed FPKM were 165.84, 241.95, 294.21 and 342.30 g, respectively. Data showed the increase in crude fiber intake when increasing levels of PKM or FPKM in the diets. The yield of hot carcass without giblets was not significantly affected by addition of PKM (70.14 % BW) or FPKM (69.11 % BW) compared to those fed control diet (69.95 % BW). Also, there were not any significant effects by the addition of any level of PKM or FPKM. However, the yield of hot carcass slightly decreased up to 20 % when PKM or FPKM were added to the broilers diet. Percentage of carcass was the same trend as those had been reported [8-9,17]. Although the nutritive value of FPKM was enhanced by solid state fermentation with *A. wentii* [7] and previous study fermented with *A. niger* reported by Khin [18] and Mirnawati *et al*. [19], but it is still limited as a poultry ration. Khin [18] noted that the feeding trial carried out in broilers (maximum level of *A. niger* fermented palm kernel cake 20 %) showed no beneficial effect of using the fermented substrate as a ration component in the poultry feed. Perez *et al*. [20] reported that egg production was significantly decreased with 50 % PKM in the diet. Feed conversion was not affected by any level of PKM (0 - 40 %). Specific gravity of eggs was slightly but significantly decreased by all levels of addition of PKM. They concluded that in laying hens, up to 40 % PKM could be used in the diet.

In this current study, the relative liver weight showed a quadratic affect in both feeding PKM and FPKM. The relative weight of the spleen was linearly affected only when the birds were fed with FPKM. The results were probably due to the influence of the fungal toxin during the solid state fermentation. Reports by Khin [18] showed that birds fed a diet containing PKC fermented by A. *niger* showed some lesions of ochratoxicosis where the immune organ (bursa of Fabricius) was adversely affected (20 % included in broiler ration). However, lesions on the organ were not investigated in this experiment.

Relative weights of all organs found in this study were consistent with the findings of Hernandez *et al*. [21], Huang *et al*. [22] and Havenstein *et al*. [23]. Gizzard and heart weight as a percentage of live BW of birds linearly increased with increasing levels of FPKM in the diets, consistent with the effect of increasing crude dietary fiber intake. Onwudike [24] showed that as palm kernel meal dietary fiber content increased, gizzard weight of broiler chicks also increased. Hetland *et al*. [25] demonstrated in laying hens that consumption of 4 % of feed as wood shavings resulted in a 50 % heavier gizzard. The feeding program affected the giblets (gizzard, liver and heart) of turkeys as reported by Laudadio *et al*. [26] and the heart yield of geese was affected by the rearing system [27].

In this study, all experimental diets were adjusted to be isocaloric by using palm oil. Htin [28] found that the diets rich in saturated fatty acids increased abdominal fat and crude fat percent of thigh meat of chicks as compared to diets rich in polyunsaturated fatty acids. Barbour *et al*. [29] also noted that when corn-soybean diets were supplemented with soybean oil levels of 20 or 40 g/kg, there was a linear decrease in the percentage deposition of abdominal fat pad in diets containing low metabolizable energy (2,940 to 2,965 kcal/kg). Disagreement was found in this present study, broilers fed the control diet had the highest amount of abdominal fat pad. An abdominal fat pad linearly decreased as levels of PKM or FPKM increased. However, the fat pad percentage was comparable with that reported by Chuysongkham [9]. The lower abdominal fat pad was possibly due to the higher amount of NSPs or fiber intake in the diets containing PKM or FPKM. Bello *et al* [17] reported that NSPs increased the viscosity of the intestinal content and thereby affected nutrient absorption and utilization.

Conclusions

The nutritive value of fermented PKM was enhanced by solid-state fermentation with *Aspergillus wentii* TISTR 3075, the yield of hot carcass carried out in broilers showed no negative effect of using the fermented substrate as a ration component in broiler feed. The relative weight of broilers liver changed quadratically when levels of PKM or FPKM were increased in their diets. The heart and spleen were little affected by PKM, whereas *A. wentii* fermented PKM were linearly affected. The weight of gizzards of broilers fed with FPKM increased linearly when broilers were fed with increasing levels of FPKM; but the trend for broilers fed with PKM was not significant. The abdominal fat pad linearly decreased with increasing levels of PKM and FPKM.

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